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MANAGEMENT TOOLS CASE STUDY, (U)

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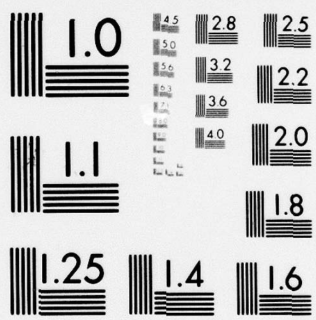

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Final Technical Report
September 1979

MANAGEMENT TOOLS CASE STUDY

Boeing Computer Services Company

John R. Brown
Linda S. Hammond

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This study investigated documentation and procedures for the NASA Integrated Programs for Aerospace Vehicle Design (IPAD) Program. The purpose was to assess IPAD's value to a proposed R&D program for evaluating the application of management principles and disciplines to the management of software development. To determine the actual relationship between IPAD objectives and the application of management techniques, a survey was given to key IPAD management and technical personnel. A summary of the responses is presented in Appendix C.

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The report discusses: key responsibilities; formal and infor.al direction; status, progress, and performance indicators. A generalized management tool model is presented to summarize the studied relationships between status indicators, program objectives, management techniques (MT), MT indicators, and key responsibilities. Hypothetical IPAD Situation Scenarios were generated to illustrate the steps taken in the IPAD environment to implement the management practices and tools studied. The report contains sample reports and forms as well as checklists.

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EVALUATION

The software industry has experienced serious problems with cost overruns, late deliveries, poor reliability and customer dissatisfaction. It has been claimed that there are no disciplined ways to determine the qualifications of available resources; no uniformly agreed upon methods of assessing performance; no reliable ways to predict the ultimate costs and schedule or the impact of changed or external events.

It is evident that other industries are less susceptible to these problems, primarily because there has been a deliberate attempt to apply basic engineering principles in a disciplined fashion.

RADC TPO R5A, Software Cost Reduction in one of its thrusts, addresses the managerial aspects of Software Definition, Design, Construction, and Verification. In this thrust the goal is to characterize or model software in terms of its three distinct basic processes: Production of the items to be delivered; Assessment of that production for status, performance, and progress indications; and Planning (and re-planning) of production activities based upon assessment data.

One purpose for generating process descriptions is to provide a framework for guiding future R&D activities related to software development and production management. These related activities were seen as consisting of three types: (1) definition of software engineering policies, methods and standards; (2) assessment of tools, existing and potentially new, in terms of benefits to be derived through their deliberate incorporation into the software production processes; and (3) preliminary design of an advanced Software Cost/Schedule Tracking System.

Before embarking on such a modeling effort, it was deemed desirable to identify a large on-going development program for which a concerted effort was made to select and employ modern software engineering practices to the maximum extent practical. We felt that such a real world referent would be an excellent basis for generating and validating the desired models. One such program, NASA's Integrated Programs for Aerospace Vehicle Design (IPAD), was identified as a candidate.

This contractual effort, Management Tools Case Study, was undertaken to determine whether the IPAD Program would be a satisfactory environment within which a thorough and conclusive evaluation of modern software management tools and methods could be accomplished. During the course of the contract, five tasks were accomplished via review of

documentation and reports, interviews with management and technical individuals, and through completion of a comprehensive questionnaire. Research indicated that at least 19 indicators of project status, progress and performance are available on IPAD. The relationships and dependencies between program objectives, management techniques, indicators of status, progress and performance, program responsibilities, and indicators of technique effectiveness were incorporated into a generalized management tool model. This Final Report describes the model, summarizes the survey results, details the techniques used on IPAD, and through hypothetical scenarios, illustrates the relationship between communicated direction and identified development objectives.

Roger W. Weber
ROGER W. WEBER
Project Engineer

1.0 INTRODUCTION AND SUMMARY

1.1 BACKGROUND/OBJECTIVE

The software industry has experienced serious problems with cost overruns, late deliveries, poor reliability and customer dissatisfaction. A common rationale for these problems, voiced both by the developers and the buyers of computing software, is that software production is a set of essentially unmanageable activities. It is claimed that there are no disciplined ways to determine the qualifications of available resources; no uniformly agreed upon methods of assessing performance; no reliable ways to predict the ultimate costs and schedule or the impact of changes or external events.

It is evident that other industries are less susceptible to these problems, primarily because there has been a deliberate attempt to apply basic engineering principles in a disciplined fashion. While the software industry seems enamored of the term "software engineering", disciplined application of engineering principles to the software production process has been rare.

For example, one basic engineering principle is that activities comprising a process should be "staged" in an orderly fashion, to guarantee that products from one activity are available in a timely fashion for subsequent activities. In software production, however, this principle is not generally implemented. The documentation of requirements, designs and plans for the software system are activities which are frequently postponed (if they are performed at all), even though this

documentation is the basic framework upon which the software itself should be built.

Engineering, As it is applied to other industries, is concerned with three distinct processes: Production of the items to be delivered; assessment of that production for status, performance, and progress indications; and planning (and re-planning) of the production activities, based upon the data the assessment process provides. The production process concerns itself principally with technical activities; the assessment and planning/re-planning processes are complementary managerial activities. BCS believes that it is possible to apply the same engineering or management principles long used in other industries, such as bridge building and airplane manufacturing, to software production; i.e., that software development is essentially a fabrication process subject to proven techniques for monitoring and planning.

In seeking to confirm the above-stated belief, Boeing Computer Services (BCS) Company is conducting a Rome Air Development Center (RADC) funded investigation of the documentation and procedures for the NASA Integrated Programs for Aerospace-Vehicle Design (IPAD) Program. The investigation will assess IPAD's value to a proposed Research and Development Program for evaluating the application of management techniques (principles, disciplines) to the management of software development.

1.2 PROJECT APPROACH/SCOPE

In order to determine the suitability of IPAD as a vehicle for evaluating the use of management techniques in software development, five independent but strongly related tasks will be performed.

1.2.1 Task 1

Examine IPAD documentation and identify management techniques being applied to the project. Documentation concerning the following items was investigated:

- Work Breakdown Schedule
- Milestone Schedule
- Review Schedule, Plans, Objectives, Participants
- Detailed Task Assignments
- Procedures, Forms, Tools
- Organization Structure

1.2.2 Task 2

Examine IPAD documentation relative to the customer's program objectives, the contractual agreement, and the statement of work to determine the development objectives of IPAD. Elicit the cooperation of IPAD management to determine the relationship between development objectives and management techniques actually being applied.

1.2.3 Task 3

Identify IPAD individuals with key functional responsibilities and determine what formal and informal direction these individuals have received. Relate the formal and informal direction upon which these individuals rely to discharge their responsibilities to the development objectives identified in Task 2.

1.2.4 Task 4

Identify specific indicators used by IPAD to assess status, progress and performance. These indicators will be determined from the management plan and the individuals with key functional responsibilities identified in Task 3. Relate these indicators to

the development objectives identified (in Task 2) and the direction communicated (in Task 3).

1.2.5 Task 5*

The indicators which IPAD is using to assess status, progress and performance shall be related to the Management disciplines or techniques being applied. An analysis will be made of the overall relationship between individuals with key responsibilities viewing indicators of status which give insight into techniques used to manage the project and achieve the program objectives.

1.3 OVERVIEW

The interim report covered work performed under Tasks 1 and 2, identified in the previous section. Candidate management techniques and development objectives were identified. In order to determine the relationship between the techniques and objectives, a survey/questionnaire was prepared and conducted using key IPAD management and technical personnel. The survey results are presented in Section 4 of this document.

Tasks 3, 4 and 5 were researched and documented from May to December, 1978. Key individuals were identified and interviewed and documentation was studied. A generalized management tool model was developed to illustrate the relationship between techniques, objectives, indicators of status, progress and performance, indicators of technique effectiveness and individuals with key responsibilities. The model is presented in Section 7.

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*Task 5 added via an Engineering Change Proposal on September 13, 1978.

2.0 IPAD ENVIRONMENT

2.1 IPAD DESCRIPTION

The IPAD system is a general purpose interactive computing system developed to support engineering design processes. Its primary function is to handle engineering data and management data associated with the design process. It is intended to support continuous design activities of a typical company mix of multiple development projects. IPAD serves management and engineering staffs at all levels of design (conceptual, preliminary, and final) and aids in the assembly and organization of design data for manufacturing processes.

The IPAD system design will support generation, storage and management of large quantities of data. Its capacity will only be limited by the hardware configurations selected by each company. The system is intended for use in a distributed computing environment having one or more central host computing systems and many remote computing systems. The number of terminals supported may range to several hundred and may be distributed across the host and remote systems. The IPAD software will function on the "third generation" computer complexes in use today by large aerospace corporations.

2.2 IPAD MANAGEMENT TECHNIQUES

Examination of IPAD documentation, in conjunction with the BCS Systematic Software Development and Maintenance (SSDM) Project Management Guide, has identified many candidate management techniques. These techniques can be

grouped in three broad categories which generally depict their function within a software development project. These categories are: 1) Project organization and administration, 2) Project planning and 3) Project evaluation and control.

Project organization and administration includes management techniques used to organize the technical staff, assemble the project's resources, establish a method for assigning and delegating work responsibility and project communication, and evaluate the quality of the project's technical work.

Project planning includes the essential elements of the project plan, a mechanical means to schedule a project's work tasks through the systematic allocation of project resources, and established standards of performance.

Project evaluation and control includes functions which assess the project's overall progress. Methods for analyzing fiscal reports, techniques for conducting project reviews, and approaches toward corrective action and change control are examples of project evaluation and control techniques.

2.2.1 Project Organization and Administration

2.2.1.1 Project Manager Concept

The project manager has total responsibility and authority to lead a team of qualified, skilled individuals to accomplish the goals of the project. He has to maintain technical and resource control at all times. He will separate and delegate the project management responsibilities and authorities to other key members of the team, thus allowing him to focus his attention on general, long-term project direction, financial/schedule control and external interfaces. An assistant project manager may be appointed to conduct overall day-to-day operations.

2.2.1.2 Work Breakdown Schedule/Structure (WBS)

Describes the subdividing of project effort. The total project work is divided into major groups, the groups subdivided into tasks, and so on. The lowest level of subdivision is small enough to permit control and visibility without excessive administrative "red tape". Work performed in major elements is the sum of all the work specified in the elements below it.

The work breakdown is sometimes accompanied by a schedule of task milestones in a graphical and/or tabular form. The graphical WBS can also incorporate a colored horizontal bar which indicates status and progress in relation to plan.

2.2.1.3 Team Organization

The organization of a team to depart from the normal "programmer type" organization. The project manager determines the mix that accommodates personality differences while allowing for satisfaction of user needs.

2.2.1.3.1 Egoless Teams

The team designs the code, individuals produce it, and all members review it. The team gives assurance that each functional module is understood and complete.

2.2.1.3.2 Chief Programmer Teams

A group of specialists organized to support top-down development. A Chief Programmer designs and produces all the code for the critical sections, defines programmer support, reviews design and code produced by others and controls its integration into the total system.

2.2.1.4 Programmer's Handbook

A loose-leaf binder containing written information and communications needed by programmers. The handbook contains:

a. Description of technical requirements
b. Baseline design
c. Support software
d. Test procedures
e. Hardware resources available
f. Summary of documentation plan
g. Programming and documentation standards

2.2.1.5 Project File

A set of management data which provides for centralization of information about the project and its activities. Contains:

a. Reports, information for accounting purposes
b. Project plan
c. Minutes of meetings and reviews
d. Correspondence
e. Documentation of findings, conclusions, recommendations
f. Worksheets and other analyses
g. Change Requests
h. Project Performance Data
i. Problem Reports
j. Lessons learned
k. Location of major project documentation

2.2.1.6 Software Notebook

A summary notebook produced for each functional module of project work. It focuses attention on process, component and module documentation, thereby enforcing the idea that documentation should evolve throughout project development. It is a collection of development and test information and supports detailed planning of project effort and status. It is used to accomplish planning and control of components, units and modules. The first page of the notebook is generally a summary sheet containing a list of the many tasks which are necessary to complete the module. For example, it is likely to contain due dates, completion dates, as well as the names of the originator and reviewer.

2.2.1.7 Support Library

Tool used for storing and recording computer program development data. It includes all computer and manual procedures needed to manipulate library data, guaranteeing that once a module has been placed in a controlled library, changes are not made without author knowledge. Its design permits isolation and delegation of record keeping and clerical operations. It includes:

- source code (in human readable form) of official copy
- object code (in machine readable form) of official copy
- control data

As the development effort continues, test data, source and object code and information to support the management of the outdated or revised versions of a module are added to the library.

2.2.1.8 Personnel Selection Requirements Form

A form used as a tool for personnel selection. It aids in the analysis of individual requirements and development of a staff training plan. Skill requirements are used as the criteria for identifying and selecting project members.

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2.2.1.9 Work Authorization Form

A formal means for delegating work in the project environment which makes the work itself accountable. It is a tool to be used when planning and scheduling project activity. As a minimum, it includes specific budgets, schedules and descriptions of the work to be done.

2.2.1.10 Project Control Room

A tool for promoting good project communications. A room assigned to the project for their exclusive use which is suitable for review meetings, working sessions, and display of project data.

Usually a project room will contain displays of detailed schedules, budget cost charts, delinquent items, action item assignments, project technical performance, status assessment, critical path events, test results, etc.

2.2.1.11 Formal Inspection of Design Documentation and Code

Formal way of independently reviewing the quality of project design, documentation and code. Techniques included in this category are walk-throughs, inspections, and QA reviews and audits.

2.2.1.11.1 Walk-through

A series of reviews, each with different objectives and occurring at different times during the development process. Typically, it is a presentation of a module's metacode or control graph, where the author/programmer "walks" the other team members through the module logic and data flow. Team members evaluate program logic to detect errors and assure thorough testing of each module. A report documenting the results of the walk-through is usually produced.

2.2.1.11.2 Inspections

A more formalized review which requires more planning, has more visibility and assumes more management involvement than a walk-through. Provides a way to capture statistics on the types, the numbers and the places where errors occur. These statistics act as feedback to the development team and project management.

2.2.1.11.3 Quality Assurance Reviews and Audits

Independent QA Reviews conducted at critical points during software development to ensure requirements satisfaction, completeness of design specification, verification of module interfaces, and adequacy of development and independent testing.

2.2.2 Project Planning

2.2.2.1 Resource Allocation Sheets

Provide a formal way for distributing the project staff to elements of the WBS. Establishes activity start and completion dates, determines schedule for facilities, clerical needs, machine times and user involvement. It is essentially a bar chart showing calendar time horizontally and project resources vertically. Normally all Resource Activity Sheets are summarized on Master Activity Sheets which are a selected listing of WBS items.

2.2.2.2 Resource Requirements Summary

Denotes the resources necessary to execute the project. It shows schedule dates, staff distribution, required facilities and machine times. Typically, it is combined with estimated resource cost to become a management planning tool.

2.2.2.3 Programming Standards

Well-defined enforceable standard programming practices with specific emphasis on those which require the production of structured code. Standards to be considered include comment and specification statement usage, data item initialization, statement ordering and common storage, data item and array conventions.

2.2.2.4 Incremental Development

Definition of progressively more complete increments of system capability. Each increment or release provides an independently testable level of the evolving system.

2.2.2.5 User Involvement Planning

Create and maintain a user interface to ensure in-depth involvement of users and provide timely review and feedback of system development information. As a minimum, there should be explicit definition of:

- user review attendance
- user feedback at critical project points
- documentation of important user opinions and recommendations

2.2.2.6 Industry and Technical Involvement Plan

Create and maintain an interface with a wide range of industry and technical experts with related experience. These experts review and critique all major technical plans and give advice about the technical feasibility and acceptability of the product.

2.2.2.7 Documentation Standards

Detailed outlines for each of the deliverable and transition documents. The documentation must be tailored to the needs of the audience/user. Documentation should be thoughtfully discussed between the customer and developer at some time prior to the system bid and a documentation plan should be developed. Simply citing an applicable standard or Contract Data Requirements List (CDRL) format is not enough since it merely highlights the government administrator and not a "manager."

2.2.3 Project Evaluation and Control

2.2.3.1 Software Development Tools

Usage of general purpose or specifically designed support programs at various points during development to assist requirements analysis, design, code generation, debugging, testing and documentation. Generally, the tools fall into two areas:

a. Requirements Definition and Analysis Tools - Tools to aid in developing a complete, consistent, unambiguous specification which can serve as a requirements baseline. A given specification can be analyzed to check for completeness and consistency to validate its content prior to design and coding.

b. Design Representation and Testing Tools - Tools developed to aid in the specification, analysis and validation of preliminary and detail design activities.

2.2.3.2 Complete Preliminary Design

Define, document and baseline a complete preliminary design. It should include identification of top-level software components, data base definition, scheduling and interface information, and critical algorithm analysis.

2.2.3.3 Software Configuration Management

Establish and follow formal software management principles. These principles specify a formal means for problem and change reporting, change control and version control. Accurate and complete identification, accounting, control and auditing of the elements needed to develop a software system are all part of configuration management.

2.2.3.3.1 Change Control Board

Responsible for the disposition and authorization of proposed changes. The Board verifies change request compliance with contractual requirements and assures the identification, evaluation and consideration of technical reasons for the change.

2.2.3.3.2 Blockpoint Change Control

A change control device for indicating when the approved change request will be completed and released. The project manager accumulates the change activity and determines resource availability, work priority and personnel selection for each change.

2.2.3.4 Requirements Specification Breakout/Baseline

Develop, review, gain customer acceptance and document the software requirements specification to be used as a formal baseline. The approved baseline ensures mutual understanding and formal written agreement of requirements.

2.2.3.5 Technical, Schedule and Cost Reports

Detailed reports submitted regularly (weekly, monthly, quarterly) to control costs, scheduling, and make project progress highly visible. These reports should be automated and must be approved and signed by the project manager. Reports include, as a minimum, estimated versus actual costs and schedules.

2.2.3.6 Independent Test Evaluation

A formal organization within the project (but separate from the project's design and development organization) which is responsible for developing test strategy and performing an independent test and evaluation of software parallel to system development. Independent testing involves analysis of software requirements, planning, preparation, and performance of tests, review of test results, discrepancy reporting and retesting.

2.2.3.7 Project Checkpoints/Milestones

Established at each software development phase in the project to delimit stages of project evolution and to provide a means for control. Checkpoints or milestones may also be representative of production of major documents or project deliverables.

2.2.3.8 Checkpoint Reviews

A formal review after each project checkpoint or milestone to verify that work performed is satisfactory and follows the project's quality standards.

2.2.3.9 Status Reviews

An internal review, conducted on a periodic basis or upon demand, which discusses project status and technical, resource or logistical decisions.

2.3 IPAD DEVELOPMENT OBJECTIVES

Examination of IPAD documentation relative to the customer's program objectives, the contractual conditions and the statement of work has identified development/ management objectives for the project.

These development/management objectives are grouped in three categories which describe the nature of the objectives. Management life cycle objectives are those which concern the progress and status of the project work. User interface objectives reflect the desire to establish and maintain good communication between the users/customers and the project team. Objectives of technical excellence reflect concern that the final product be in accordance with requirements, dependable, reliable and of overall high quality.

2.3.1 Management Life Cycle Objectives

2.3.1.1 On Schedule

Achieve intermediate and final milestones on or before scheduled completion dates.

2.3.1.2 Under Cost

Accomplish individual and cumulative tasks at or below proposed cost.

2.3.1.3 Status Visibility

Provide for a high degree of visibility into IPAD development status.

2.3.1.4 Problem Recognition and Correction

Provide for rapid recognition of project problems and equally rapid identification and implementation of necessary corrective action

2.3.1.5 Contractor Commitment

Demonstrate high-level contractor commitment to the IPAD program.

2.3.2 User Interface Objectives

2.3.2.1 User Involvement

Incorporate a high degree of user involvement in both definition and periodic assessment of IPAD system features and functional capabilities.

2.3.2.2 Usefulness Demonstration

Provide early demonstration of the ultimate feasibility and general utility of the IPAD system.

2.3.2.3 Satisfy Diverse Needs

Provide for satisfaction of the diverse needs of the broadest possible set of users (i.e., aerospace vehicle designers of the 1980's).

2.3.3 Technical Excellence Objectives

2.3.3.1 Standard/Procedure Compliance

Demonstrate strict compliance with self-imposed standard practices and procedures.

2.3.3.2 Reliability and Dependability

Ensure maximum reliability and dependability of the IPAD system.

2.3.3.3 Configuration Management

Provide for organized, effective control of changes to the IPAD system configuration.

2.3.3.4 Machine Independence

Ensure maximum machine independence of the IPAD software.

2.3.3.5 Maintainability

Ensure maximum maintainability (easy modifiability) of the IPAD system.

3.0 SURVEY DESCRIPTION

3.1 SURVEY OBJECTIVES

In order to determine the actual relationship between IPAD objectives and the application of management techniques, a survey was given to key IPAD management and technical personnel. There were two purposes of the survey. We sought first to determine which of the candidate general management techniques (detailed in Section 2.2) are currently being applied or are proposed to be applied to IPAD and secondly, to identify specific instances in which the management techniques applied to IPAD were effective contributors toward achievement of the stated objectives.

3.2 SURVEY TECHNIQUE

The survey was divided into three parts. The first part contained the list of development objectives detailed in Section 2.3. The participants were asked to prioritize the objectives. That is, within the context of IPAD, they were asked to identify the most critical objective, next-most critical objective, and so on.

The second part contained a list of the candidate management techniques which were detailed in Section 2.2. The participants were asked to indicate whether they believed the techniques were currently being applied, were proposed to be applied, or were not planned to be applied to IPAD.

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The third part of the survey/questionnaire was a matrix which had candidate management techniques on the horizontal axis and development objectives on the vertical axis. The participants were asked to relate the objectives to the techniques actually used to accomplish the objectives. If the technique had a strong positive effect upon achieving the objective, the participant entered an S in the corresponding matrix element. If the technique had only a moderately positive effect toward objective achievement, the participant entered an M in the matrix element. If the participant felt that the technique had no effect (or an uncertain effect) on achievement of the objective, the matrix element was left blank.

3.3 SURVEY RESULTS

Survey participants prioritized the thirteen objectives on a scale of 1 (high priority objective) to 13 (low priority objective). The results were summarized into three categories: high, medium and low priority. Responses with a rank from 1 to 4 were classified as high priority, 5 to 8 as medium priority, and 9 to 13 as low priority. A summary of the results of prioritization appears in Appendix A.

Participants next gave each candidate management technique a score which indicated, to the best of the participant's knowledge, the technique's application to IPAD. A score of 1 indicated that the technique was currently being used. A score of 2 indicated that the technique was not currently being used, but was proposed for use as the project progressed. Finally, a score of 3 indicated that the technique was not being applied and was not proposed to be applied to IPAD.

The results of this part of the survey were summarized into three categories. Techniques with a score of 1 or 2 were grouped together since they represented techniques which were applied or were to be applied to IPAD. The number of techniques with a score of 3 were totaled. In addition, some participants indicated that they had no personal knowledge of the technique application. These indications were summarized under a third category. A table which summarizes the results of the second part of the survey appears in Appendix B.

The third part of the survey indicated whether the participant felt the techniques had a strong (S), moderate (M), or uncertain (blank) effect toward objective accomplishment. A summary of the responses is presented in Appendix C. Each element of the summary matrix has been divided into two parts. The upper part of the element contains the total number of strong positive responses, while the lower part reflects the total number of moderate positive responses.

4.0 SURVEY RESULTS

4.1 SURVEY - PART 1

After reviewing the survey results of Part 1 (see Appendix A), a few conclusions can be made. The objectives which were ranked as first, second, and third by the participants are Satisfy Diverse Needs, User Involvement and Usefulness Demonstration. It is important to note that these three objectives were categorized as objectives which aid the user interface. As stated in the IPAD Requirements document "The principal objective of IPAD is to provide a computer software system which will aid the U.S. Aerospace Industry in the design of future vehicles." From this statement, and other evidence of emphasis on the user interface, it is apparent that the participants were somewhat biased in their prioritization due to contractual (NASA) requirements. That is, the three highest ranked objectives would probably receive lower ranks if surveyed in a more general atmosphere.

The objectives of Contractor Commitment and Reliability and Dependability were ranked next highest. A high level of contractor commitment is desirable on all software projects. As one participant commented, "it is implied by the contractor's bid and must therefore be ranked very high."

Maintainability, which some sources estimate consumes 70% of software dollars, is ranked low by IPAD. Again, the emphasis on technical quality supercedes the concept that the system should be easily modifiable. The contract does

not specifically call out the objective of maintainability, it does call for a product which passes certain acceptance tests.

4.2 SURVEY - PART 2

Part 2 of the survey/questionnaire was designed to determine which of the candidate management techniques (identified in Section 2.2) are being applied or are proposed to be applied to IPAD.

Of the thirteen survey participants, ten responded to Part 2 of the survey. These ten participants had expertise in most aspects of the IPAD program and were qualified to respond to Part 2. Some of the 10 participants felt unqualified to respond to elements of Part 2 of the survey. These responses have been grouped separately. Part 2 survey results have been summarized in Appendix B.

Sixteen of the thirty-two management techniques were unanimously identified as having current or proposed IPAD application. In addition, ten more of the techniques were unanimously identified as being applied by those participants with personal knowledge of the technique's use. The technique titled "Work Authorization Form" was identified by all but one participant as being applied on IPAD. Survey results for the remaining five techniques deserve closer analysis.

Two techniques, "Egoless Teams" and "Design Representation and Testing Tools," were identified as being applied by six participants, not being applied by two participants, and having unknown application by two participants. Due to lack of positive indication of the use of these techniques, it appears that they are not among the management techniques being systematically applied to IPAD.*

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* During research for Task 4, a technique for "Design Representation and Testing Tools" was found to be under development by IPAD. IPAD evaluation of the usefulness of techniques is an ongoing activity and new technology is constantly being introduced in the Software Tools area. Therefore, it can be expected to find a technique under development which was not a part of the original project plan.

The technique "Chief Programmer Teams" had an almost equal number of responses in each of the three categories. Again, due to lack of positive indication of the use of this technique, we must assume that it is not being systematically applied on the IPAD program.

The two techniques which remain to be interpreted are "Personnel Requirements Form" and "Requirements Definition and Analysis Tools." These techniques have been identified by the majority of participants as techniques which are not being applied to IPAD.

In summary, it appears that twenty-eight* of the original thirty-two management techniques have been identified as having current or proposed IPAD application, while four* techniques are not being systematically applied or do not have enough positive evidence to indicate application on IPAD.

4.3 SURVEY - PART 3

4.3.1 Modeling

The primary objective of Part 3 of the survey/questionnaire was to define the relationship between the stated objectives and the management techniques being applied on IPAD.

Selection of a modeling method to evaluate the responses to the survey/questionnaire involved the development and use of a technique to measure the objective/technique relationship identified by survey participants. A mathematical algorithm was developed to summarize and analyze the response data. The algorithm used to obtain an index for each element of the matrix is:

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* Including Design Representation and Testing Tools

$$\text{Index} = \left(\frac{S + M}{T} \cdot \frac{3S + M}{3T}\right)$$

where:

T is the total number of survey participants
S is the number of strong responses for the element
M is the number of moderate responses for the element

This algorithm evaluates the response data in two ways. The first part of the algorithm evaluates the strong (S) and moderate (M) responses for each matrix element as if they had equal weight. The second part of the algorithm incorporates the idea that strong (S) responses have much more (3 times more) weight in the analysis than moderate (M) responses.

The rationale behind the second part of the algorithm is the nature of the S and M responses themselves. To indicate that a management technique has a strong (S) effect toward accomplishment of an objective, the participant must have been firmly convinced of the existence of a technique/objective relationship. However, if the participant felt that the technique had some effect on the objective, but was unsure of the strength of the effect, he would be likely to respond that the effect was moderate (M). In light of the nature of S and M responses, the weight of S responses should be greater than M responses. Through iterative use of different weight schemes on assumed survey responses, a final weighting factor of 3 was arrived upon.

4.3.2 Example

The iterative method for determining the weight of strong (S) and moderate (M) responses was supported by assumed survey responses. These assumed responses were used in place of the S and M variables in the algorithm presented in Section 4.3.1. To illustrate the algorithm, these assumed responses and final results using

the algorithm are shown in this section. Figure 4.3.2.1 shows an example of assumed responses for a matrix with two objectives (Objectives A and B) and three techniques (Techniques A, B, and C). In this example the sample size was thirteen.

	Technique A	Technique B	Technique C
Objective A	S - 6	6	10
	M - 4	6	3
	blank - 3	1	0
Objective B	S - 2	0	4
	M - 4	13	6
	blank - 7	0	3

Figure 4.3.2.1
EXAMPLE SURVEY RESPONSES

Using these assumed survey responses, the algorithm is used to determine an index for each of the six elements. The indices produced by the algorithm are shown in Figure 4.3.2.2.

	Technique A	Technique B	Technique C
Objective A	.43	.57	.85
Objective B	.12	.33	.36

Figure 4.3.2.2
INDICES OF OBJECTIVE/TECHNIQUE RELATIONSHIP

The indices indicate that Technique C has the most significant effect on Objective A. This outcome is not surprising since 10 participants felt that the technique had a strong positive effect on the objective.

Observe the index results for Objective A/Technique A and Objective B/Technique C. The results show that Objective A/Technique A has a higher index. Although there were a total of 10 responses in the S and M categories for each element, the index of Objective A/Technique A is higher due to the weighting of S responses with a factor of 3.

4.3.3 Summary Survey Results

The detailed results for Part 3 of the survey are presented in Appendix C. There are far too many individual elements of the matrix to permit detailed discussion of the assessed relationship of each stated objective to each of the management techniques. Elements of the matrix can be disregarded due to lack of substantial positive evidence of the objective/technique relationship. As an element filtering device, all matrix elements which have less than three responses in both the S and M categories can be disregarded. In addition, five columns of the matrix which represent management techniques not applied on IPAD (see Section 4.2) can be disregarded from Part 3 interpretation. Elements of the matrix which remain after the filtering described above has been performed are then evaluated using the algorithm described in Section 4.3.1. The composite indices which are derived from the use of the algorithm are presented in Appendix D. These indices range in value from .03 to .95.

At this point it is evident that response data which does not indicate a strong objective/technique relationship remains to be filtered from the matrix. To do this it is necessary to group the response data into "domains." The following domains were selected for the final element filtering:

Response Index Domain	Data Categorization
0.0 - 0.14	Inconclusive relationship
0.15 - 0.49	Moderate Positive relationship
0.50 - 1.0	Strong Positive relationship

Looking closely at these domains, it may appear that the Moderate and Positive categories have a wide range and are skewed high. For example, it may seem unreasonable to specify that indices of 0.50 and above are indicative of a strong objective/technique relationship. Normally, an upper domain would fall in the 70-80 percentile category. However, one must consider the effect of the indexing algorithm upon the response data. The algorithm specifies that two fractions must be multiplied together to obtain the composite index. When two fractions are multiplied, the result is a smaller fraction. For instance, if the first fraction in the algorithm (indicating the total number of positive responses related to total participants) was relatively high - .8 or eighty percent - and the second fraction (which weights strong responses) was also .8, the composite index would be .64 or sixty-four percent. If the upper domain was related to indices of .70 or above, this example index would have been classified as moderate. Intuitively, the relationship would have been classified as strong. For this reason, the domains used in this analysis were adjusted as necessary to approximate intuition and permit the lumping of objective/technique relationship indices into the broad categories.

The final filtered results of Part 3 of the survey/questionnaire are presented in Appendix E. Those elements which fell into the 0.0 - 0.14 domain are indicated by a blank and therefore make the strong (S) and moderate (M) indices readily visible.

As Appendix E shows, there are 10 strong and 65 moderate objective/technique relationships. The strong and moderate relationships identified occupy 75/416 or 18 percent of the original matrix of objectives and techniques.

The number of strong and positive elements prohibits detailed discussion of each element in this report. However, only a brief glance at the Part 3 summary identifies some particularly interesting objective/technique relationships which are illustrated below.

A few management techniques were identified which appeared to be useful toward achievement of many objectives. Those with the highest apparent usefulness were:

Project Manager Concept
Software Notebook
Reviews and Audits
User Involvement Planning
Industry and Technical Involvement
Change Control Board

In addition, some of the development objectives were identified as having many management tools which had a strong or moderate effect toward achievement of the objective.

Figure 4.3.3.1 illustrates the objectives which are strongly effected by certain management tools.

Objective	Strongly Effected by
On Schedule	Project Manager Concept
Under Cost	Project Manager Concept
Usefulness Demonstration	User Involvement Planning
	Industry and Technical Involvement
Status Visibility	Project Control Room
	Reviews and Audits
User Involvement	User Involvement Planning
Configuration Management	Change Control Board
	Blockpoint Change Control
Satisfy Diverse Needs	User Involvement Planning

Figure 4.3.3.1
STRONG OBJECTIVE/TECHNIQUE RELATIONSHIPS

Status Visibility was identified as having 11 techniques which had a moderate effect and 2 techniques which had a strong effect.

Configuration Management was moderately effected by 4 techniques and strongly effected by 2 techniques.

Standard/Procedure Compliance was moderately effected by 10 techniques.

There are some instances in which the effectivity index (i.e., the observed objective/technique relationship) does not match either our intuition or statements of intent. Such instances can be attributed to poor survey response data, ambiguous description of the objective or technique, or simply that a chosen technique measures up as less powerful than advertised. Investigation of these instances and resolution of the cause will be a subject of subsequent reports on the findings of the Management Tools Case Study.

5.0 INDIVIDUAL RESPONSIBILITIES AND DIRECTION

5.1 KEY RESPONSIBILITIES

To identify individuals within IPAD with key functional responsibilities, a list of individuals was obtained from the Management Plan. This list was shown to the IPAD Software Development Manager to ensure that all individuals had been identified. A few names and titles were added and a draft of the revised Management Plan was provided which contained textual descriptions of key responsibilities in planning, controlling, reviewing and assessing project activities. It is appropriate to define what the terms planning, controlling, reviewing, and assessing mean and imply.

Responsibilities in planning are concerned with devising a scheme for making, doing or arranging project activity. Controlling responsibilities imply regulating, directing and exercising authority over the course of project activities. Responsibilities in reviewing concern the formal inspection or critical evaluation of project activities. Assessing responsibilities relate to judgment of the worth, importance or value of project activities.

The central individuals in the planning, controlling, reviewing and assessing efforts are the Program Manager (PM) and the Assistant Program Manager. The PM is responsible for the technical approach and content of the engineering and software products, cost and schedule control, the interface between the development team and the Industry Technical Advisory Board, and for total IPAD contract performance. The emphasis of the PM is on long-term, general direction while day-to-day

functional management is delegated to other managers. The Assistant Program Manager supports the PM through complementary (rather than duplicative) responsibilities which are of the near term, day-to-day program operations nature. The Assistant Program Manager provides overall daily technical integration and coordination, assists the PM in review preparation (and any resulting action item follow-up), and is the focal point for all contract deliverables.

The PM delegates responsibility and authority to other IPAD managers. The following sections contain textual descriptions of the responsibilities of the key IPAD individuals. These descriptions were obtained from a draft of the revised Management Plan and may, therefore, be subject to minor modifications.

5.1.1 Business Manager (BM)

The Business Manager has the responsibility of preparing all monthly and quarterly schedule and cost reports; of reviewing cost and schedule performance; of establishing and maintaining the IPAD control room; and of interacting with Contract Administration in defining and negotiating contract questions. He has the authority to access Boeing Company records for the purpose of extracting relevant cost data for reporting and performance review; and to require relevant resource and schedule data from other functional group heads. He will assist Program Support in the purchase or rental of computing facilities. He is responsible for defining the requirements for program physical facilities and coordinating the installation of those facilities.

5.1.2 Industry Technical Advisory Board (ITAB) Interface Manager

The ITAB Interface Manager has the responsibility of preparing the User Involvement Plan; of organizing and managing the functioning of ITAB; and to correlate IPAD developments with Boeing engineering and manufacturing organizations.

He is responsible for contacting ITAB representatives for the purposes of organizing meetings, communicating technical information, and conducting critiques. He will also contact the management and technical personnel of IPAD users, as directed by NASA, to arrange or negotiate communication, training, etc.

5.1.3 Engineering Development Manager (EDM)

The Engineering Development Manager has the overall responsibility for the engineering tasks on the IPAD Program. These tasks essentially cover user functional requirements, reviews of software design, software acceptance and training. He is assisted by key personnel with responsibilities for engineering process definitions, product manufacturing interface definitions, information processing requirements, and user functional requirements. New responsibilities will be assigned to key personnel consistent with later phases of the program involving such tasks as acceptance testing, and training. He will work with the ITAB Interface Manager in corresponding with and obtaining reviews by ITAB members or other members of the using community.

He has the authority to specify and prepare with NASA concurrence, or as directed by NASA, technical computer programs and data bases to be used for demonstration, installation and acceptance testing; to accept or reject software specifications, designs and release definitions based upon their compliance with the engineering functional requirements; and to accept or reject all IPAD software installations based upon the acceptance tests. The integration of engineering and software technology is the responsibility of the Assistant Program Manager. Conflicts between engineering and software development will be resolved by the Program Manager.

5.1.4 Software Development Manager (SDM)

The Software Development Manager has overall responsibility for all computing-related activities on the IPAD project including organizing, planning, directing,

controlling, and reporting. He has responsibility for the cost, schedule, and quality performance of all computing tasks on the program.

The Software Development Manager will develop the organizational structure for the systems group that will best achieve system objectives and prepare job descriptions for all key personnel showing clear lines of responsibility, decision-making authority, and well defined accountability. He will obtain the necessary staff required, coordinate training requirements and conduct an effective training program, monitor personnel performance and conduct performance reviews for the systems staff, and coordinate consultation support, as required.

He will ensure that planning activities are conducted so that tasks and activities have clearly defined objectives, task dependencies, priorities, risks, milestones, and responsibilities as well as realistic estimates and schedules and will document and present such plans for review by the Program Manager. He will review and approve all subordinate plans in the areas of user involvement, development test, acceptance test, incremental release, training, documentation, and configuration and control.

The Software Development Manager will initiate policies and procedures for the performance of software development activities including planning, estimating, design, construction, testing, maintenance, resource usage, training, and general administration. He will ensure that the systems team is properly motivated to deal with their responsibilities and with personal problems that might interfere with the performance of their duties. This responsibility includes handling all communications external to the systems group and coordinating the systems team's required involvement in those communications to minimize the impact on their work load.

The Software Development Manager will also deal with all administrative responsibilities of the systems organization and make (or obtain) decisions in a timely manner to keep the project moving without undue delays. He will monitor and review the IPAD project's progress in the areas of cost, schedule, and quality performance; anticipate and identify problems and incorporate contingency plans to

deal with them; and evaluate personnel performance and take corrective action as required.

The Software Development Manager will report to the program management on manpower and skill requirements, schedule and resource utilization, technical status of milestones and deliverables, and problems with resulting impacts and contingency actions taken.

5.1.5 Technical Director/Chief Designer (CD)

The Technical Director is responsible for the design, construction, development testing, maintenance, and documentation of the IPAD computing system. He will ensure that these items are correct, compliant with the contract statement of work and the IPAD requirements, and consistent with IPAD software development standards. He is responsible for preparing for reviews of the computing technical work, presenting the results of such work at those reviews, and for responding to action items and recommendations that result from those reviews.

The IPAD Technical Director/Chief Designer is the leader of the IPAD design team, which consists of the IPAD Systems Integrator/Assistant Chief Designer and the IPAD System Technical Leaders for the following functions: 1) Methodology; standards, and tools; 2) Distributed computing system; 3) Data management system; 4) User interface; 5) User functions; and 6) Geometry/graphics.

The IPAD Technical Director/Chief Designer is responsible for planning technical tasks under his control or delegating such tasks to the IPAD Systems Integrator/ Assistant Chief Designer or to the appropriate IPAD System Technical Leader(s). He directs key people in carrying out planned tasks, establishes software development standards, and acquires the methods and tools that will be used to support the IPAD computing tasks.

The IPAD Technical Director/Chief Designer will define the manpower requirements of the computing staff. He will identify training and technical consultation requirements and commercial sources of IPAD system software components and will provide assistance in completing IPAD software development tasks.

The IPAD Technical Director/Chief Designer (AD) has the authority to approve the computing task plans and end items, and he will approve computing standards, methods, and tools used to support the software development tasks. He is directly accountable to the IPAD Software Development Manager for the planning, conduct, completion, and quality of all IPAD software development tasks. He reports on the status of IPAD system technical tasks to the IPAD System Development Manager.

5.1.6 IPAD Systems Integrator/Assistant Chief Designer (AD)

The IPAD Systems Integrator/Assistant Chief Designer will assist the Chief Designer in consolidating all of the IPAD component designs into a total system design at each level of detail, maintaining a log of design decisions and unresolved design problems, and identifying task interdependencies between the development teams.

As IPAD Systems Integrator, he will primarily be responsible for technical assistance in the resolution of IPAD system problems, drawing upon the expertise of computing specialists, engineers, and others as necessary.

From the results of the various design teams, the IPAD Systems Integrator will ensure production of a complete, consistent, integrated design. He will continually review 1) technical designs, especially for compatibility with identified program/SOW requirements, and 2) design and documentation for conformity to applicable standards. He will also schedule, coordinate, and conduct technical reviews and work sessions relative to design integration and their problem identification and resolution.

The IPAD Systems Integrator/Assistant Chief Designer will provide technical support in the form of review responses; coordinate design document production; identify and coordinate resolution of conflicts between design and documentation; develop an IPAD user's manual; participate in software design and development experiments; assist in training activities; and provide support to the IPAD operations organization as appropriate.

5.1.7 Technical Leader--Methodology, Standards and Tools (TL)

Under the direction of the Technical Director/Chief Designer, the Technical Leader--Methods, Standards, and Tools, will define and document software development procedures, standards, and general software engineering methodology for the IPAD project and will devise necessary tools and aids to support such development. This task consists of the subtasks described in the following paragraphs:

Establishing standards for IPAD software development documents--This subtask involves defining the content and format of the: a) IPAD Requirements Document, b) Preliminary Design Document, c) IPAD Detail Design Document, and d) IPAD Program Document.

Establishing review procedures for major IPAD software development tasks and results--This subtask defines the expected results, material to be reviewed, procedure for conducting a review, and responsibilities for each major review. Procedures apply to reviews to be conducted at Boeing; however, they may also be used by NASA for conducting Intermediate Design Reviews (IDR) and Critical Design Reviews (CDR). These IPAD reviews cover: a) Requirements; b) Preliminary design; c) Detail design; d) Program construction, testing, and evaluation; e) Program and documentation acceptance test; and f) Installation.

Formulated software development methods--This subtask will formulate and document methods to be used in defining, developing, describing, testing,

evaluating, installing, and maintaining IPAD software. Such methods include: a) Requirements analysis; b) Preliminary design; c) Detail design; d) Program construction; e) Program evaluation; f) Program testing; g) Program installation; and h) Program maintenance.

Identify, acquire, and implement software development tools and aids--This subtask is for the purpose of identifying, acquiring, and implementing tools and aids for the development of the IPAD program when limited amounts of time and resources and little or no modifications are required. Tools and aids include: a) Module workbook, b) Coding standards, and c) Program modification and library maintenance.

Establish software development reporting standards and procedures--This subtask will define the content, format, and application of the following reports to be published by the IPAD Software Development Group: a) Technical status, b) Technical problems, and c) Technical bulletin.

5.1.8 Program Support Manager

The Program Support Manager has the responsibility of preparing the documentation and configuration control plans, managing and developing the dedicated development computer, packaging software for delivery, preparing final art text for formal contract documents, and for establishing and maintaining the IPAD Program Support Library.

5.1.9 IPAD System Technical Leaders--Major Components

Under the direction of the Technical Director/Chief Designer, an IPAD System Technical Leader is responsible for the design, construction, development testing, and documentation of one or more specific major IPAD system components, as assigned. Each Technical Leader will ensure that: a) These items are correct; b) Designs satisfy their requirements; c) Programs satisfy their design specifications;

and d) Designs, programs, and documents produced by his team conform to IPAD Software Development Standards. Each Technical Leader is responsible for planning the tasks of his team; for day-to-day technical problem-solving assistance to his team; for seeking assistance from the Chief Designer in such problem-solving, as necessary; and for defining manpower, schedule, and training requirements. He shall participate in the preparation and presentation of technical reviews.

Each IPAD System Technical Leader has the authority to carry out planned tasks in the area for which he is responsible when such plans are approved by the IPAD Technical Director/Chief Designer. He shall approve or disapprove the designs, software modules, or document units produced under his direction.

5.2 FORMAL AND INFORMAL DIRECTION

Project communication between the key individuals previously identified occurs through formal and informal channels. The formal or administrative relationship that the individuals communicate through is shown in Figure 5.2-1.

Notice that the Program Manager and the Assistant Program Manager are depicted as sharing responsibilities at the same level. This separation of program management responsibilities is meant to focus the Program Manager's attention on general, long-term program direction, financial/schedule control and external requirements. The Assistant Program Manager then directs the daily program operations.

The Software Development Manager and the Technical Director share a supportive role also. The Software Development Manager deals with all the administrative responsibilities of the systems group, freeing the Technical Director to deal with design, construction, development testing and maintenance details.

The key individuals identified in Section 5.1 receive formal and informal direction when fulfilling their designated responsibilities.

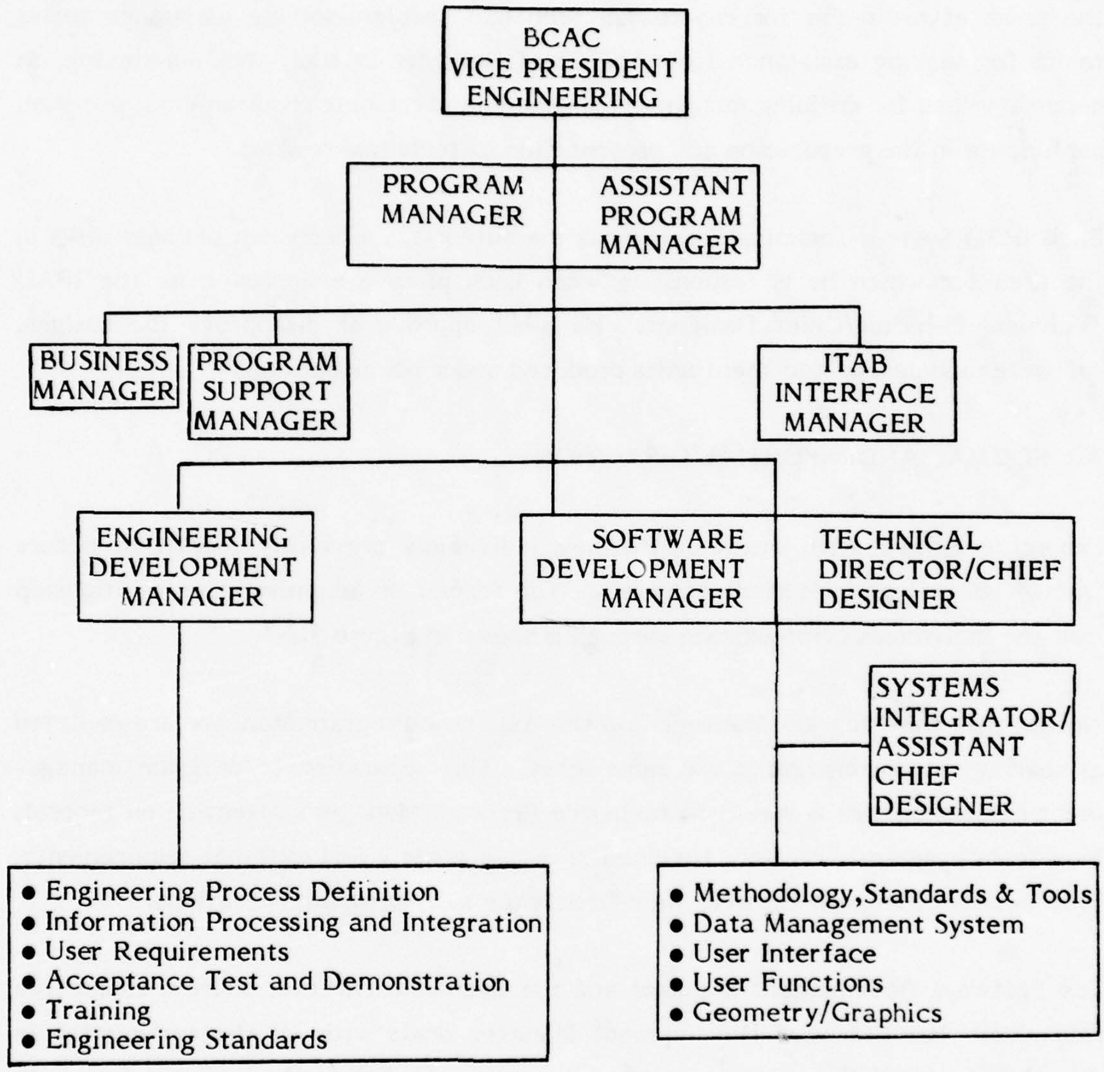

Figure 5.2-1 FORMAL PROGRAM ORGANIZATION AND REPORTING RELATIONSHIPS

Formal direction is premeditated and usually written down. It consists of policies, procedures, standards and communication at all levels (i.e., headquarters, company, district and division are Boeing levels) which must be followed by individuals when carrying out functional responsibilities.

Informal direction may be written down but is usually in the form of oral communication. This kind of direction is usually a result of a problem which has occurred and was not anticipated, therefore no formal direction was specified. Generally, problems occur and a solution is devised, documented and implemented. Informal direction may be given as a result of the level of expertise of key individuals, or it may be acquired through current literature in the field.

Formal and informal direction was investigated via the Management Plan and through conversations with some of the individuals with key responsibilities.

Generally, the following types of formal and informal direction were identified:

Formal Direction

- Boeing and BCS internal procedures
- Boeing and BCS operating procedures
- Boeing and BCS Contracts Group
- Boeing and BCS Finance Group
- NASA Reporting Procedures, Documentation Standards
- IPAD Statement of Work
- IPAD Proposal
- IPAD Feasibility Study
- IPAD Requirements
- Formal reviews of both documents and tasks by NASA, IPO and ITAB
- Direction through lines of organizational structure
- IPAD Review Procedures
- IPAD Coding Standards

- DOD Industrial Security Regulations
- IPAD Software Development Standards

Informal Direction

- Experience
- Training, Lectures, Demonstrations
- Informal Reviews of documents and tasks by NASA, IPAD Project Office (IPO), and ITAB
- Problem Sessions, self-study workshops
- NASA Technical Bulletins
- NASA documents on structured programming and top-down design
- SSDM Phased-Development Approach methodology
- Current literature in related areas
- Standards at other companies
- RADC series on Structured Programming
- American National Standards Institute (ANSI) Standards
- IPAD Team Members
- Comparison with similar historical project activities
- Computing Specialists
- Boeing Data Center Specialists

Each key individual uses formal and informal direction in a different manner. The following paragraphs discuss the way each of the individuals identified earlier use formal and informal direction.

The Business Manager relies on formal direction from the Boeing Finance and Contracts groups to determine the content and frequency of various cost and schedule reports. NASA Reporting Procedures and documentation standards also provide formal direction of report content and format. When defining physical facility requirements he is assisted by formal Boeing and BCS operating procedures which apply to lease/buy decisions.

Informally, the Business Manager is directed by his own experience and training as well as that of other IPAD team members.

The ITAB Interface Manager receives formal direction from the IPAD Proposal and the IPAD Statement of Work. These documents define the format and content of the User Involvement Plan, the number and types of ITAB members as well as functional responsibilities of ITAB members.

Informally, he relies upon his experience and that of IPAD team members and Boeing to determine the ITAB members and to conduct ITAB reviews.

The Engineering Development Manager receives formal direction through the IPAD Feasibility Study, the IPAD Statement of Work (SOW), IPAD Requirements, formal reviews by ITAB, IPO and NASA, BCS and Boeing Commercial Airplane Company (BCAC) internal procedures. Each of these kinds of formal direction assist him in determining and complying with the functional requirements of IPAD, conducting software design reviews, and software acceptance and training.

BCAC specialists and documentation provide informal direction when establishing the product manufacturing interface definitions. The content and format of training materials is informally directed by the experience of the Engineering Development Manager and other members of the IPAD team as well as that of other experts in the field.

The Software Development Manager relies on BCS and BCAC procedures and policies as well as the SOW and Proposal when defining the organizational structure of IPAD. When reviewing the cost and schedule of project activities he relies on the formal assistance of the Business Manager and the Boeing Finance group.

Some facets of organizational structure development are informally directed by the experience and judgement of the Software Development Manager. He also relies on

his experience and that of other members of the IPAD when initiating policies and procedures in planning, estimating and design.

The Technical Director/Chief Designer uses the IPAD Requirements, SOW and established standards as formal direction to ensure that items of the computing system are correct and satisfy requirements. Policies established by IPAD set formal guidelines for review content and format.

Informally, past experience of the IPAD managers and the IPAD team, as well as current related literature and NASA and BCS guidelines aid in the development of coding standards and development testing.

Formal direction to the Systems Integrator is provided to consolidate the design components and resolve problems by the IPAD Management Plan, SOW and IPAD requirements. A design representation and analysis tool is available to assist testing of the design for completeness and consistency, however, use of this tool is not required.*

The Technical Leader receives formal direction from the Chief Designer and the NASA IPAD project office in the development of standards, software development procedures and the software engineering methodology.

A good deal of his work is informally directed through reference to NASA design standards documents, BCS Systematic Software Development and Maintenance (SSDM), current literature in the field, military standards, standards from other

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*During initial research the tool was under development, however, development of the tool was discontinued. A preliminary version of the tool which serves to document the design and provide some rudimentary analysis capabilities is available for IPAD use.

companies, Boeing Standards, NASA Technical Bulletins and the RADC series on Structured Programming. In addition, standards established by the American National Standards Institute (ANSI) are informally used.

The Program Support Manager is formally directed by the IPAD SOW, NASA documentation Standards, the IPAD Feasibility Study, Boeing Standards, DOD Industrial Security Regulations and the IPAD Contract Schedule in preparation of the documentation and configuration control plans. BCS, BCAC, Boeing Data Center, and NASA procedures for configuration control and program support libraries are used when applicable.

The Program Support Manager relies heavily on his many years of experience in configuration control and program support. He has an established rapport with the Boeing Data Center as well as with other Boeing individuals whom he relies upon for knowledge and aid in problem correction.

The System Technical Leaders are formally directed by the Technical Director/Chief Designer. They rely upon the SOW and IPAD Requirements to ensure that the design satisfies the contractual requirements. The standards developed by the Technical Leader of Methodology, Standards and Tools, are used by the other Technical Leaders to determine conformance to project standards.

When defining manpower, schedule and training requirements for a major IPAD system component, the Technical Leaders rely on their experience as well as comparison with similar historical project activities. An automated tool (called Project Control/70) which contains records of previous project schedule and manpower requirements is informally relied upon to compile component resource requirements. In addition, all members of the component development team participate in the planning process. This participation ensures accurate estimation and allows other team members to gain valuable experience.

5.3 RELATION BETWEEN DIRECTION AND PROGRAM OBJECTIVES

To verify the research into formal direction, dependence on informal direction, and to initiate determination of the relationship between direction and the program objectives, we formulated three hypothetical scenarios illustrative of typical problems and situations often encountered in major software development efforts. Briefly, these hypothetical scenarios depicted:

a) A requirements change during a Critical Design Review (CDR).
b) A design deficiency discovered by the IPAD Technical Advisory Board (ITAB).
c) Concern about an acceptable measure of testing sufficiency during a Preliminary Design Review (PDR).

The scenarios have been more fully described in Appendix F, Hypothetical IPAD Situation Scenarios.

These hypothetical scenarios were distributed to the IPAD Software Development Manager for study and resolution. The Software Development Manager consulted IPAD team members who would be responsible for scenario resolution and produced lists of steps which would be taken to resolve the hypothetical scenarios. These lists have been reproduced in Appendix G, IPAD Scenario Resolution.

The scenarios were illustrative of direction received, responsibilities fulfilled and actions taken to resolve hypothetical problems. They provided evidence of a strong relationship between formal and informal direction and IPAD team member responsibilities.

The resolution of the scenarios did not give evidence of a strong, explicit relationship between the program objectives and formal and informal direction. An all-encompassing methodology which attempts to show that a specific form of formal or informal direction will accomplish a particular program objective cannot

be derived. There exist components of formal and informal direction which cannot be predefined and are therefore not measurable. Examples of such components are personalities and individual experience and capability.

However, the scenarios were illustrative of the manner in which dispatching of responsibilities relates to the achievement of program objectives. In essence, corrective action (to resolve the scenarios) occurred through the dispatching of responsibilities. In this way, satisfaction of program objectives can be achieved by expediting responsibilities.

To provide an illustration of the manner in which responsibilities satisfy program objectives, the scenarios were used in conjunction with definitions of responsibilities set forth by Robert D. Melcher in a paper entitled "Roles and Relationships: Clarifying the Manager's Job." Melcher defines types of managerial responsibility:

A. General Responsibility - The individual guides and directs the execution of the function through the person delegated operating responsibility.

B. Operating Responsibility - The individual is directly responsible for the execution of the function.

C. Specific Responsibility - The individual is responsible for executing a specific or limited portion of the function.

D. Consulted - The individual, if the decision affects his area, must be called upon before any decision is made or approval is granted, to render advice or relate information, but not to make the decision or grant approval.

E. Notified - The individual must be notified of action that has been taken.

F. Approve - The individual (other than persons holding general and operating responsibility) must approve or disapprove.

A matrix was constructed which depicted the scenario corrective steps (from Appendix G) vertically and key IPAD individuals horizontally. For each step, the individuals having the types of managerial responsibilities described above were identified. Next, each corrective step was assumed to have been initiated to

achieve one or more of the thirteen program objectives identified earlier. Objectives which were associated with the corrective steps were identified in the rightmost column of the matrix. Figure 5.3-1 illustrates the matrix representing Scenario 1.

In this case, the first step in scenario resolution was IPAD Program Manager's (PM) notification of the Critical Design Review action item. The PM has specific responsibility to direct the overall execution of tasks in order to accomplish the requirements change hypothesized by Scenario 1. The NASA IPAD Project Office (IPO) must approve the action item which resulted from the supposed CDR. Program objectives 4 and 12, Status Visibility and Contractor Commitment, respectively, are supported by Step 1. By notifying the PM and the NASA IPO, a high degree of visibility is afforded to the action item. PM notification provides contractor (BCS) commitment at a very high level.

Each of the steps for processing the action item associated with Scenario 1 has been evaluated in a like manner and is documented in Figure 5.3-1. Scenario 2 steps were likewise evaluated and the results appear in Figure 5.3-2.

The use of scenario resolution steps in conjunction with definitions of managerial responsibilities defined by Melcher has helped to show the strong relationship of responsibilities to program objectives.

Study of the development/management objectives supported by the functional events of all scenarios as depicted in Figures 5.3-1 and 5.3-2 will show that not all the objectives were supported by the set of steps. This occurs due to the situations depicted by the scenarios. That is, the objectives not listed (Nos. 1, 2, 3, 6, 7, 11 and 13) would be supported by scenarios depicting different situations. For example, a scenario concerning the assessment, evaluation and replanning of a scheduled WBS task would support objectives 1 and 2 (among others).

STEPS - FUNCTIONAL EVENTS	IPAD PROGRAM MANAGER	ASSISTANT PROGRAM MANAGER	BUSINESS MANAGER	ITAB INTERFACE MANAGER	ENGINEERING DEVELOPMENT MANAGER	SOFTWARE DEVELOPMENT MANAGER	TECHNICAL DIRECTOR/ CHIEF DESIGNER	INTEGRATOR/ ASST. CHIEF DESIGNER	PROGRAM SUPPORT MANAGER	PROGRAM CONTROL COORDINATOR	TECHNICAL LEADERS	NASA-IPAD PROJECT OFFICE	BCAC CONTRACTS CONTROL	COMPUTING GROUP STAFF MEMBER	DEVELOPMENT/MANAGEMENT OBJECTIVES SUPPORTED *
1. NASA CDR Board Chairman gives action item to Program Manager.	S											A			12,4
2. Route to APM for technical evaluation and routing.	S	S													10
3. Forward to Senior SW.D. Mgr. for evaluation and task delegation.		S				S									10 (Problem Recognition)
4. Senior SW Mgr. assigns task of formal statement to IPAD Mgr. of Requirements.						S	G								10 (Problem Recognition)
5. Manager delegates formal statement of responsibility to Staff member.							G							0	10 (Problem Correction)
6. Staff member prepares formal statement, contacts PCC for configuration control.										N				0	8,10 (Problem Correction)
7. PCC and Staff Member fill out Change Request and Impact Summary, submit to Mgr.							C			S				0	8,10 (Problem Recognition)
8. Manager completes CCR form and returns to PCC.							S			N					8
9. PCC logs CCR, distributes change package to managers and sets up CCB meeting.	N	N	N	N	N	N	N	N	N	S	N				8,4
10. CCB considers package, orders full impact analysis or signs CCR and PCC routes it.	N	A	A		A	A	A	A	A,S	S					8
11. PCC logs CCB decision and if approved sends to PM for concurrence.	A									S					8
12. PM Reviews CCR, returns to PCC to forward to NASA.	A									S					12,4

Figure 5.3-1 RESPONSIBILITIES FOR SCENARIO 1 (Page 1)

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STEPS - FUNCTIONAL EVENTS / FUNCTIONAL RESPONSIBILITY	IPAD PROGRAM MANAGER	ASSISTANT PROGRAM MANAGER	BUSINESS MANAGER	ITAB INTERFACE MANAGER	ENGINEERING DEVELOPMENT MANAGER	SOFTWARE DEVELOPMENT MANAGER	TECHNICAL DIRECTOR/ CHIEF DESIGNER	INTEGRATOR/ ASST. CHIEF DESIGNER	PROGRAM SUPPORT MANAGER	PROGRAM CONTROL COORDINATOR	TECHNICAL LEADERS	NASA-IPAD PROJECT OFFICE	BCAC CONTRACTS CONTROL GROUP	COMPUTING STAFF MEMBER	DEVELOPMENT/MANAGEMENT OBJECTIVES SUPPORTED *
13. PCC forwards to NASA.										S		A			4
14. NASA reviews for approval; if accepted, returns to PCC.												A			5
15. PCC turns package over to ATMS typist who updates Master File, returns it to PCC. PCC then routes to Mgr. for release.							A			S					8
16. PCC sends revised CCR to printing for copies, then distributes to individuals.										S					8,4

Legend

A = Approval Responsibility
G = General Responsibility
S = Specific Responsibility
O = Operating Responsibility
C = Consulting Responsibility
N = Must be Notified
* Numbers correspond to objectives detailed in Section 2.3

Figure 5.3-1 RESPONSIBILITIES FOR SCENARIO 1 (Page 2)

STEPS - FUNCTIONAL EVENTS \ FUNCTIONAL RESPONSIBILITY	IPAD PROGRAM MANAGER	ASSISTANT PROGRAM MANAGER	BUSINESS MANAGER	ITAB INTERFACE MANAGER	ENGINEERING DEVELOPMENT MANAGER	SOFTWARE DEVELOPMENT MANAGER	TECHNICAL DIRECTOR/ CHIEF DESIGNER	ASST. INTEGRATOR/ CHIEF DESIGNER	PROGRAM SUPPORT MANAGER	PROGRAM CONTROL COORDINATOR	TECHNICAL LEADERS	NASA-IPAD PROJECT OFFICE	BCAC CONTRACTS or FINANCE	CONTROL GROUPS ENGINEERING STAFF MEMBER	DEVELOPMENT/MANAGEMENT OBJECTIVES SUPPORTED*
1. ITAB initiates action item to Program Manager.	C			S								C			12,5,9
2. PM assigns EDM to correct design document as required.	S				G										10 (Problem Recognition)
3. EDM initiates plan and delegates study to engineer.					G								S	S	10 (Problem Recognition)
4. Engineer and PCC discuss CCR, involve EDM.					C					S				S	10,8
5. CCB meets, document update required.	N	C	C	C	C	C	C	C	C	S	C				8,10 (Problem Correction)
6. EDM opens account, assigns engineer to establish CCR.					S					S			S	S	8,10
7. CCB meets and approves update.	N	A	A	A	A	A	A	A	A	S	A				8,10
8. CCR approved by PM, sent to NASA; NASA approves.	A									S		A			12,5,8,10,4
9. Document updated, CC maintained; copies distributed to managers.	N	N	N	N	N	N	N	N	N	S	N				4,8,10 (Problem Correction)
10. Changes reported at next ITAB meeting.				S											9,4,5

Figure 5.3-2 RESPONSIBILITIES FOR SCENARIO 2

It should also be pointed out that the use of Robert Melcher's definitions of responsibilities is a very limited use of part of a tool he has developed called the Management Responsibility Guide (MRG). The MRG is a planned and systematic approach to group and related managerial functions in a manner to aid an organization and objectively solve its organizational problems.

6.0 STATUS, PROGRESS AND PERFORMANCE INDICATORS

6.1 GENERAL INFORMATION

Task 4 calls for determining (through key people and by studying the Management Plan) what indicators IPAD is using to assess status, progress and performance. It is appropriate to define what the terms status, progress and performance mean and imply.

Status is a set of circumstances or attributes which characterize a person or thing at a particular time. This imples that a status indicator is that which provides explicit evidence of the state or condition of the IPAD program.

To progress means to move forward or onward; to advance toward completion or a higher state. This has several implications: first, that there exists a thing which is uncompleted; second, that progress can be measured as an increment or change in the status of something. Progress indicators of the IPAD program give evidence of the change in status.

Performance is the execution, accomplishment or fulfillment of something or some task. To perform a task implies some sort of operation or functioning, usually with regard to effectiveness. That is, the ingredients of performance are productivity as well as worth or value. Performance indicators on IPAD give evidence of the efficient consumption of effort to accomplish a task effectively and with a degree of technical excellence.

6.2 MONITORING STATUS, PROGRESS AND PERFORMANCE

Monitoring of status, progress and performance is aided through the use of the Work Breakdown Structure and the Work Authorization Form. The principle program management control mechanism is the Work Breakdown Structure (WBS) and the monitoring and review of design and development technical performance relative to planned schedule and cost of work breakdown items. The following figure, copied from the IPAD Management Plan, indicates the pervasive use of the WBS in IPAD. As Figure 6.2-1 illustrates, the WBS is the basis for scheduling, management by the project organization, recording of costs incurred and project reporting. The formal means for delegating work in the IPAD Program environment is the Work Authorization. Work authorization consists of three things: the assignment of responsibility, granting of authority, and accounting for results. Formal accountability is achieved through use of the Work Authorization form. A copy of the current IPAD Work Authorization (WA) form is shown in Figure 6.2-2. The WA describes work to be performed for each WBS unit. When an authorization for a particular level of the WBS is issued, all supporting tasks are implicitly authorized.

6.3 IPAD INDICATORS

During research into IPAD indicators of status, progress and performance it became increasingly apparent that most of the indicators were provided through the use of the management tools and techniques discussed previously. This, however, was not surprising since the tools were chosen (by IPAD) for the aid they would provide in the areas of project administration, planning, evaluation and control.

The list which follows describes indicators which IPAD uses to assess status, progress and performance. When the indicator is provided through the use of a tool, the tool name is supplied and the list of tools (Section 2.2) should be cross-referenced since the tool description contains a general description of the indicator.

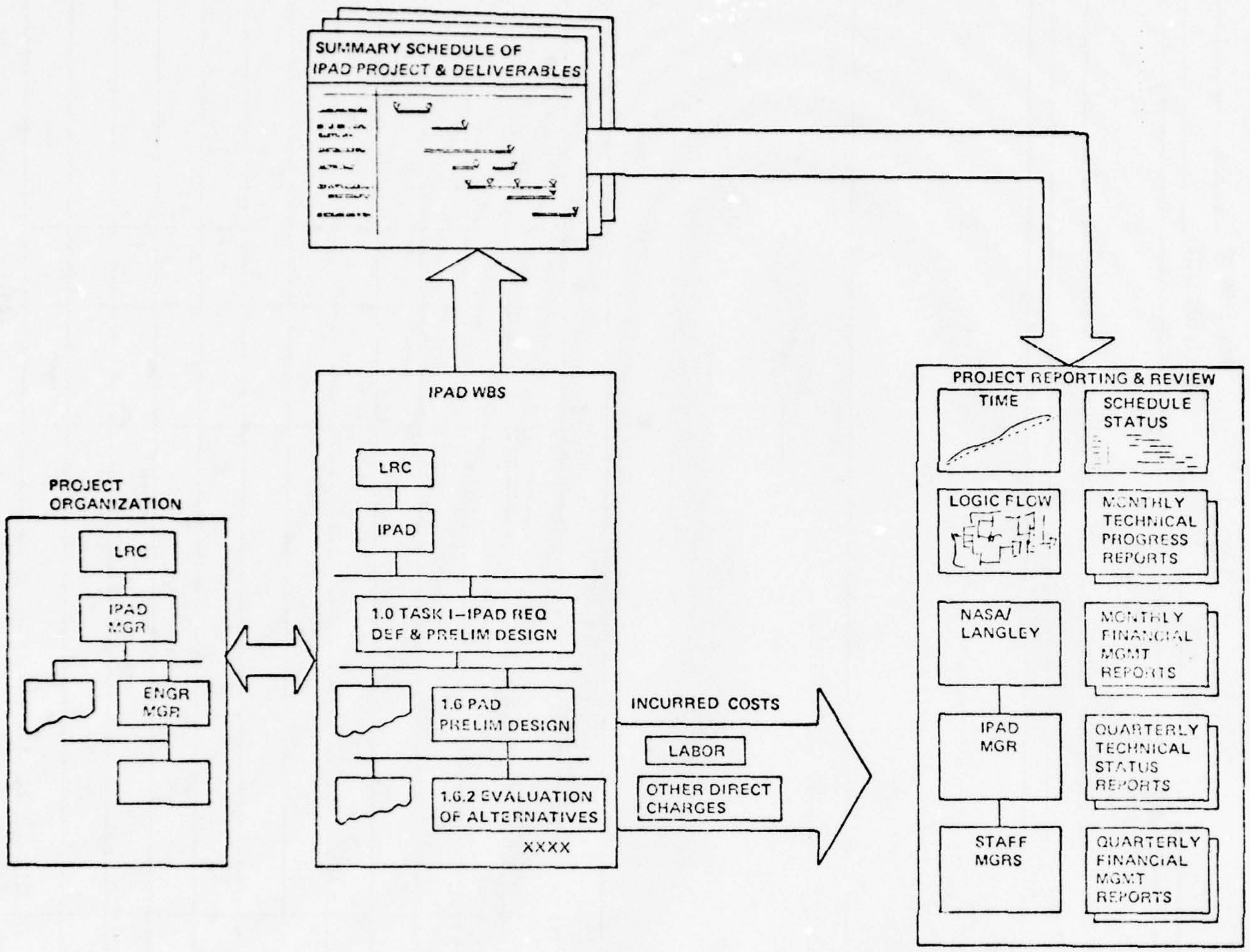

Figure 6.2-1 WBS AS BASIS OF IPAD PLANNING AND CONTROL

WORK AUTHORIZATION (WA)

PROJECT: ______________________ WBS NO: __________

ISSUE DATE: __________

REVISION NO: __________

START: __________ FINISH: __________ REVISION DATE: __________

CRITICAL PATH ☐ YES ☐ NO

PREDECESSOR TASKS: ________ ________ ________ ________ ________

SUCCESSOR TASKS: ________ ________ ________ ________ ________

DESCRIPTION:

EXPECTED OUTPUTS, RESULTS, AND MILESTONES:

SUPPORTING WBS SUBTASKS

WBS NO.	DESCRIPTION	ASSIGNED	EST. HRS.	SUBTASK PREDECESSORS

TEAM MEMBER SIGNATURE: ______________________ DATE: __________

TECHNICAL MANAGER SIGNATURE: ______________________ DATE: __________

Figure 6.2-2 SAMPLE IPAD WORK AUTHORIZATION FORM

1. The Project File, as a centralized base of project information, contains status, progress and performance indicators. Status indicators are in the form of reports, correspondence, documentation of findings, conclusions, recommendations and change requests. Progress indicators are minutes of reviews and meetings, and reports. Performance indicators can be found in documentation of findings, conclusions, and recommendations, minutes of reviews and meetings, worksheets and other analyses, project performance data and documentation on problems and lessons learned.

2. The Software Module Workbook (also called the Software Notebook) of IPAD contains two kinds of data; that which will be included in design documents, and that which is included to provide management with an understanding of implementation status. Design document information includes module program listings, figures and diagrams. Status, progress and performance visibility is provided through the following types of information:

   - Walk-through Approval Sheets
   - Implementation Plans
   - Test Results
   - Discrepancy Reports

   Walk-through Approval Sheets are the result of the structured walk-through and certify that the module being reviewed is either accepted or to be revised. The Approval Sheets provide quick visibility into module review/acceptance status. A copy of the Walk-through Approval Sheet is shown in Figure 6.3-2, following Item No. 5, Walk-through.

   Implementation Plans contain Work Authorization forms filled out as part of component planning as well as documentation used to generate estimates and schedules.

Test Results consist of a test summary, test results, and test case input sections. Each test is described (complete with environment specification), the results of each case are recorded, and correspondence of results with acceptance criteria are noted. The design team manager uses the Software Module Workbook to monitor module status, progress and performance.

Discrepancy Reports are used when a problem has been found in modules which have been placed under configuration control. A sample Software Problem Report is shown in Figure 6.3-6, following Item No. 12, Software Configuration Management. Although not in use by IPAD at the present time, a Software Notebook generally contains a Summary Cover Sheet like that shown in Figure 6.3-1. As the figure illustrates, the status of a module can easily be determined by glancing at the Cover Sheet.

3. The Support Library contains an official copy of the latest version of the program. The status of software construction can be determined by obtaining the number of modules stored within the library. Since the library contains archive program data, comparison of current and archive data will provide evidence of progress.

4. The Project Control room, as a tool for promoting good communications, provides evidence of status, progress and performance in relation to plan. Usually the IPAD project room contains displays on detailed schedules, budget cost charts, delinquent items, action items, project technical performance, status assessment, milestone schedules and critical events. The Project Room is the central location of evidence of status, progress and performance indicators.

5. A walk-through can provide an indication of programming quality (performance) as errors, discrepancies, exposures and inconsistencies may be identified while the programmer "walks" the other group members through the module

	DUE DATE	DATE COM-PLETED	ORIGINATOR	REVIEWER
1. REQUIREMENTS SPECIFICATION				
2. DESIGN OVERVIEW				
3. INTERFACE DESCRIPTION				
4. DATA FLOW DIAGRAM				
5. METACODE DESIGN DESCRIPTION				
6. ASSUMPTIONS AND CONSTRAINTS				
7. DESIGN TEST				
8. REVIEW OF DESIGN TEST				
9. MODULE CODE				
10. COMPONENT TEST CASE DESCRIPTIONS				
11. REVIEW OF COMPONENT TEST CASES				
12. TEST CASE RESULTS				
13. SUPPORT LIBRARY CONTROL				
14. DISCREPANCY REPORT FILE				
15. SIGN-OFF COMPLETED MODULE				

Figure 6.3-1 SAMPLE SOFTWARE NOTEBOOK COVER SHEET

logic and data flow. It also provides a measure of progress since it represents completion and review of a component.

IPAD Structured Walk-throughs follow specified rules or procedures and each participant has a designated role/function which he must fulfill. The result of an IPAD Structured Walk-through is a Walk-through Report (also called a Walk-through Approval Sheet). A sample Walk-through Report is shown in Figure 6.3-2. The Report documents the participants' responsibilities, the review agenda and review decision. The review may result in an action list of items to be resolved. By viewing the Walk-through Reports, the various IPAD team leaders have evidence of status, progress and performance.

6. Inspections provide performance indication as the program product is verified for compliance with requirements and acceptance criteria. Since inspections are a means to capture statistics about detected errors, a collection of inspection documentation should provide a good indication of project performance.

7. Quality assurance reviews and audits provide evidence of performance since they test for satisfaction of requirements, conformance to specifications and adequacy of development and independent testing. For example, each document is subject to rigorous quality assurance control. A QA Check List accompanies the document for review by the manager responsible for document development, the Quality Assurance and Configuration Control Manager, the Assistant Program Manager, and the Program Manager. A copy of this form is presented in Figure 6.3-3. This form also depicts the document review status at any time during the review cycle. A manager is able to determine whether approval has been granted by each of the other responsible managers by the presence or absence of signatures in the lower right-hand corner. Another checklist is used for quality assurance and configuration control. The form is a 50-item checklist of tasks which must be completed for each document produced by IPAD. This form is presented in Figure 6.3-5

Coordinator

Project

Coordinator's Checklist:

1. Confirm with producer(s) that material is ready and stable _____

2. Issue invitations, assign responsibilities, distribute materials

Date__________ Time__________ Duration__________
Place______________________________

Responsibilities		Participants	Can Attend?	Received Materials?
________	________	______________	________	________
________	________	______________	________	________
________	________	______________	________	________
________	________	______________	________	________
________	________	______________	________	________
________	________	______________	________	________

Agenda:

1. All participants agree to follow the (same) set of rules.

2. New project: walkthrough of material
Old project: item-by-item checkoff of previous action list

3. Creation of new action list (contributions by each participant)

4. Group decision

5. Deliver copy of this form to project management

Decision
_____Accept product as-is
_____Revise (no further walkthrough)
_____Revise and schedule another walkthrough

Signatures: ______________ ______________ ______________
______________ ______________ ______________

Figure 6.3-2 SAMPLE WALKTHROUGH APPROVAL REPORT

☐ REVIEW ☐ APPROVAL ☐ FINAL		IPAD DOCUMENT QUALITY ASSURANCE CHECK SHEET	SHEET # ______ DOC. NAME ______ DOC. NO. ______		
CHECK POINTS	STATUS OK.	COMMENTS	ITERATIONS A-CORRECTED (initials	B-CORRECTED & date)	C-CORRECTED
● FORMAT					
COVER:					
TITLE SHEET:					
[illegible] SHEET:					
ABSTRACT:					
LIMIT. & DISCL.:					
ACTIVE PAGE SHEET:					
REVISIONS SHEET:					
TABLE OF CONTENTS:					
LIST OF TABLES:					
LIST OF FIGURES:					
TBD LIST:					
ACRONYMS & ABBREV.:					
DEFINITIONS:					
SUMMARY:					
TEXT:					
INTRODUCTION:					
BODY OF DOC.:					
CONCLUSIONS:					
LIST OF REFERENCES:					
BIBLIOGRAPHY:					
APPENDICES & ADDENDA:					
● PAGE, PARA., SECTION NO.					
● COND. OF CHARTS, FIG.					
● GEN. TEXTUAL COMMENTS			APPROVED FOR RELEASE: RESP. MGR. ______ QA. & CC. ______ ASST. PROG. MGR. ______ PROG. MGR.		DATE

Figure 6.3-3 SAMPLE QUALITY ASSURANCE CHECK SHEET

following item 12 on configuration control indicators. Documentation quality assurance status can be obtained quickly by scanning the column entitled "COMPLETED BY" on this form.

8. IPAD programmers and designers must follow a detailed set of programming/ design standards. Among the design standards is the requirement that the system be developed using top-down design. Top-down techniques are followed and the problem is reduced into a set of components. IPAD components have specified characteristics. For example:

   a) It implements a defined set of functions required or implied by IPAD software specifications.

   b) The executable and comment statements (of the corresponding procedure) can be listed contiguously.

   c) The statements are enclosed by identifiable boundaries.

   d) The component can be referenced from other parts of the program only by its name or its single entry.

   e) The component will have a single, common entry and a single, common exit.

   f) The component can reference other components, suspend its execution upon encountering procedure statements, and resume execution with the next immediate statement.

   g) All called components must return to their caller at the statement immediately following the reference.

While the seven component design standards are not the complete set of design standards, they are illustrative of the conventions which must be followed. Standards such as these provide a means for evaluating design/programming performance.

9. User, industry and technical individuals review the progress and performance of IPAD. They participate in the review and assessment of such data as:

a) User Requirements
b) System interface plans/specifications
c) Software
d) Hardware Plans
e) Technical Plans
f) Training Plans
g) Test Plans
h) Test Results
i) Development Schedules
j) User Documentation
k) User Evaluation Results

The minutes (or reports) which result from user, industry or technical review are evidence of IPAD progress and performance.

10. Informal auditing of conformance to documentation standards provides an indication of the performance of the documentation development groups. The IPAD Documentation Plan specifies the standards to be followed by the various development groups. It also contains outlines of the planned contents of each document. Formal Quality Assurance and Configuration Control (see items 7 and 12) which is performed on each document provides evidence of adherence to these standards thereby yielding indicators of performance.

The Documentation Plan references applicable BCS format standards for each document. Documents are typed using ATMS (Advanced Text Management System - IBM) techniques according to specified format standards. No formal auditing of adherence to these format standards is performed. However, informal auditing occurs by the ATMS typists (who are familiar with the standards), and several IPAD managers (Program Support/Quality Assurance Manager, Program Manager, the manager responsible for document development, etc.). Formal and informal control of document adherence to standards can provide performance indicators by the number of errors detected and corrected. This information can be obtained via the Quality Assurance Check Sheet (see Figure 6.3-3).

11. Software development tools in the area of design analysis and verification provide documentation of the existing design data base, thus supplying reports indicating the status of the design effort. The system currently produces nine reports. An example of such a report provided by the Integrated Design Analysis Programs (IDAP) system is shown in Figure 6.3-4. This report, called the Full PDL Report, provides current information about components of the design, variables referenced by design modules, and the state of design decomposition. Reports which have been generated earlier in the project effort can be manually compared with current reports to provide an indication of design progress. The IDAP system has a predefined set of constructs which can be used to represent a design. The use of a construct not part of the predefined set will not be accepted by IDAP. While the IDAP system does not provide indicators of performance, use of the system must conform to standards; therefore a degree of technical excellence is implied.

It should be noted that the IDAP system was under development through IPAD funding until November, 1978. Due to time and money constraints, only the first phase of the system was completed when IPAD-supported development was discontinued. Therefore, while the first phase is available for use, the system is not highly supported by IPAD managers or designers. Design analysis

```
79/09/11.           INTEGRATED DESIGN ANALYSIS PROGRAMS            IDAP 1.0
PAGE    1                     *********                             ICL
                        COMPONENT DESCRIPTION - LONG
*------------------------------------------------------------------------*

GENERAL COMPONENT INFORMATION
   MNEMONIC       ICL
   NAME           IPEX CONTROL LOOP
   DESCRIPTN      INITAZITION AND TERMINATION PROCESSING AND PROCESSING
                  SIGNALS FROM THE HOST SYSTEM
   PARENT         IPEX
   VERSION        1.0
   REQUIREMNT     STATEMENT OF WORK 8.3
   TEST PLAN      TO BE ADDED (TBA)
   ACCPT CRIT     TBA

COMPONENT DATA DEFINITIONS
EXTERNAL DATA DEFINITIONS
   PDB          IN/OUTPUT     PROCESS DESCRIPTOR BLOCK
       PARENT           NONE

   HAS          INPUT         HOST-ASYNCHRONUS SIGNALS
       PARENT           NONE

   SRBX         INPUT         SERVICE REQUEST BLOCK(EXTERNAL)
       PARENT           NONE

   HASCB        OUTPUT        HOST-ASYNCHRONOUS SERVICE
                              COMPLETION BLOCK
       PARENT           NONE

   SRBI         IN/OUTPUT     SERVICE REQUEST BLOCK (INTERNAL)
       PARENT           NONE

   CPP          OUTPUT        CURRENT PROCESS POINTER
       DESCRIPN         A POINTER TO THE PDB OF THE CURRENTLY
                        EXECUTING IPEX INTERNAL PROCESS
       PARENT           NONE
       TYPE             POINTER TO PDB
       UNITS            NONE
       INIT VALUE       NULL
       DIMENSION        NONE

   SD           INPUT         SHUT DOWN SIGNAL
       PARENT           NONE

   DUMMY        IN/OUTPUT     DUMMY DATA ITEM
       PARENT           NONE

COMPONENT DATA DEFINITIONS
INTERNAL DATA DEFINITIONS

COMPONENT-PROCESSING DESCRIPTION
```

Figure 6.3-4 SAMPLE IDAP FULL PDL REPORT (Page 1)

```
78/09/11.           INTEGRATED DESIGN ANALYSIS PROGRAMS            IDAP 1.0
PAGE    2                       *********                           ICL
                          COMPONENT DESCRIPTION - LONG
*-----------------------------------------------------------------------*
COMPONENT-PROCESSING DESCRIPTION          - CONT -
PROCESS   INIT
          IPAD INITIALIZATION
          IN (DUMMY)
          OUT (PDB)
          I-O-D
LOOP      LOOP1
     REPEAT PROCESS    PHF
                       PROCESS HOST EVENTS
                       IN (HAS, SRBX)
                       OUT (HASCR, SRBI)
                       I-O-D
               SELECT  SELCT1
                   IF          C2
                               IF IPEX INTERNAL PROCESSES ARE READY TO PROCEED
                               EXP = SPDI NOT EMPTY
                               VAR (SRBI)
                   THEN   PROCESS    EIP
                                     EXECUTE INTERNAL PROCESS
                                     IN (PDB)
                                     OUT (CPP)
                                     I-O-D
                   ELSE   PROCESS    DIP
                                     DELAY IPEX
                                     RELINQUISHE THE REMAINDER OF THE TIME
                                           SLICE ALLOCATED TO IPEX
                                     IN (DUMMY)
                                     OUT (DUMMY)
                                     I-O-D
               END-SELCT
     UNTIL         SD
                   SHUT DOWN SIGNAL RECEIVED AND ALL IPEX INTERNAL PROCESSES
                        HAVE BEEN COMPLETED
                   EXP = SD AND SRBI IS EMPTY
                   VAR (SD, SPBI)
END-LOOP
PROCESS   TERM
          IPAD TERMINATION
          IN (DUMMY)
          OUT (DUMMY)
          I-O-D
PRCNG-END
```

Figure 6.3-4 SAMPLE IDAP FULL PDL REPORT (Page 2)

capabilities are currently being developed by an IPAD-independent group and probably will not be available for timely use on IPAD.

12. Software configuration management provides evidence of status and progress since the main thrust of the technique is to maintain the integrity of all program deliverables and other key program documentation and software. The configuration control process consists of the functions of status accounting and change control. The basic major unit of work to be controlled is a Configuration Item (CI). Usually a CI is a specific document or unit of software. The CI is identified and defined and all action toward completion of work on the CI is documented and controlled. Thus, the status and progress of a CI can easily be determined. Figure 6.3-5 provides an example of the configuration control process for document development. Each document goes through 50 steps after the initial writing has been accomplished. The first 17 steps are performed on the review copy of the document, while steps 18 to 36 are performed on the approval copy and the last 14 steps (37-50) apply to the final copy. Status of the document can easily be determined by scanning the "COMPLETED BY" column of the Documentation Process Check Sheet. In a like manner, progress can be determined by the progression of a document through this cycle.

The Software Problem Report form (also called a Discrepancy Report) is used to report detailed information about the identification, analysis and solution of software problems. Figure 6.3-6 provides a sample Software Problem Report form. Initially the form contains a description of the problem or its symptoms. As the problem is analyzed and corrected the form is used to record detailed information.

13. The requirements specification baseline, after formal customer approval, is in itself an indicator of status (completion of the requirements phase) and progress (have progressed from requirements and are ready to begin

IPAD
QUALITY ASSURANCE,
CONFIGURATION CONTROL

DOC. TITLE: ____________________

DOC. NO.: ____________________

DOCUMENTATION PROCESS CHECK SHEET

COPY	FLOW	TASK - ACTION ITEMS	RESPONSIBILITY	COMPLETED BY (initials)	DATE
REVIEW		(1) PROG. SUPPORT MGR. REVIEWS COPY.	P.S.M.		
		(2) ASST. P.M. REVIEWS COPY.	ASST. P.M.		
		(3) P.M. REVIEWS COPY. ● INTERMEDIATE EDITING, TYPING, CORRECTIONS.	P.M.		
		(4) REVIEW COPY SIGNED BY AUTHOR, RESP. MGR. ONLY. (dated as of release date)	RESP. MGR. AUTHOR		
		(5) PROG. SUPPORT MGR. APPROVES RELEASE.	P.S.M.		
		(6) ASST. P.M. APPROVES RELEASE.	ASST. P.M.		
		(7) P.M. APPROVES RELEASE.	P.M.		
		(8) A.T.M.S. FILE CLOSED.	A.T.M.S. TYPIST.		
		(9) SEND COPY TO REPRODUCTION.	P.C.C.		
		(10) RECEIVE COPY FROM REPRODUCTION.	P.C.C.		
		(11) PREPARE COVER LETTER.	P.C.C.		
		(12) SIGN COVER LETTER.	P.S.M.		
		(13) DISTRIBUTE REVIEW COPY.	P.C.C.		
		(14) SEND ORIGINAL ART TO GRAPHICS. ● ITAB MEMBERS RECEIVE REVIEW COPY.	P.C.C.		
		(15) NASA RECEIVES REVIEW COPY. ●(S.O.W. DELIVERY DATE 6 DAYS AFTER POINT (13) ABOVE) NASA/ITAB REVIEW.	***		
		(16) RECEIVE NASA / ITAB COMMENTS.	P.C.C. / RESP. MGR.		
		(17) RECEIPT OF FINAL ART FROM GRAPHICS. ● FINAL IPAD EDIT. ● PREPARE ANOTATED APPROVAL COPY FOR REVIEW.	P.C.C. / RESP. MGR.		

Figure 6.3-5 SAMPLE DOCUMENTATION PROCESS CHECK SHEET (Page 1)

IPAD
QUALITY ASSURANCE,
CONFIGURATION CONTROL

DOC. TITLE: ____________________

DOC. NO.: ____________________

DOCUMENTATION PROCESS CHECK SHEET

COPY	FLOW	TASK-ACTION ITEMS	RESPONSIBILITY	COMPLETED BY (initials)	DATE
APPROVAL		(18) PROG. SUPPORT MGR. REVIEWS COPY.	P.S.M.		
		(19) ASST. P.M. REVIEWS COPY.	ASST P.M.		
		(20) P.M. REVIEWS COPY.	P.M.		
		(21) OPEN A.T.M.S. FILE. (see above) ● INTERMEDIATE EDITING, TYPING.	A.T.M.S. TYPIST		
		(22) RESP. MGR. , AUTHOR CONCUR WITH APPROVAL COPY BY SIGNING/DATING THE CHECK SHEET.	RESP. MGR./ AUTHOR		
		(23) PROG. SUPPORT MGR. APPROVES/SIGNS COPY.	P.S.M.		
		(24) ASST. P.M. APPROVES/SIGNS COPY.	ASST. P.M.		
		(25) P.M. APPROVES/SIGNS COPY.	P.M.		
		(26) A.T.M.S. FILE CLOSED.	A.T.M.S. TYPIST		
		(27) SEND COPY TO REPRODUCTION.	P.C.C.		
		(28) RECEIVE COPY FROM REPRODUCTION.	P.C.C.		
		(29) PREPARE APPROVAL COPY COVER LETTER.	P.C.C.		
		(30) P.M. SIGNS COVER LETTER.	P.M.		
		(31) FINAL REVIEW OF COLLATED DOC./REL. O.K.	RESP. MGR.		
		(32) DISTRIBUTION OF APPROVAL COPY. ● NASA RECEIVES APPROVAL COPY. ● NASA REVIEW.NASA IPO SIGNS/MAILS TITLE PAGE.	P.C.C.		
		(33) RECEIVES NASA APPROVAL.	RESP. MGR./ P.C.C.		
		(34) SEND MATERIAL TO GRAPHICS FOR FINAL COVER/REMAINING ART WORK.	P.C.C.		
		(35) RECEIVES COVER AND FINAL ART.	P.C.C.		
		(36) OPEN A.T.M.S. FILE AS PER (33) ABOVE. (if required)	A.T.M.S. TYPIST		
		● COMPLETE FINAL EDITING, CORRECTION PROCESS BASED ON EXCEPTIONS (if any) IN (33) ABOVE.	RESP. MGR/ AUTHOR		

Figure 6.3-5 SAMPLE DOCUMENTATION PROCESS CHECK SHEET (Page 2)

IPAD
QUALITY ASSURANCE,
CONFIGURATION CONTROL

DOC. TITLE: ____________________

DOC. NO.: ____________________

DOCUMENTATION PROCESS CHECK SHEET

COPY	FLOW	TASK - ACTION ITEMS	RESPONSIBILITY	COMPLETED BY (initials)	DATE
FINAL		(37) COLLATE FINAL COPY.	RESP. MGR./ P.C.C.		
		(38) RESP. MGR. REVIEWS FINAL COPY.	RESP.MGR.		
		(39) P.S.M. REVIEWS FINAL COPY.	P.S.M.		
		(40) ASST. P.M. REVIEWS FINAL COPY.	ASST. P.M.		
		(41) P.M. REVIEWS FINAL COPY.	P.M.		
		(42) CLOSE A.T.M.S. FILE.	A.T.M.S. TYPIST		
		(43) SEND TO PRINTING.	P.C.C.		
		(44) RECEIVE FROM PRINTING.	P.C.C.		
		(45) PREPARE FINAL COVER LETTER.	P.C.C.		
		(46) SIGN FINAL COVER LETTER.	BCAC CONTRACTS		
		(47) FINAL REVIEW OF COLLATED DOC./REL. O.K.	RESP. MGR.		
		(48) DISTRIBUTE FINAL COPY.	P.C.C./BCAC DATA REC. MGMT.		
		(49) ESTABLISH MASTER COPY RECORDS/MICRO.	P.C.C./BCAC DATA REC. MGMT.		
		(50) FORMAL CONFIG. CONTROL ESTABLISHED.	P.C.C.		

Figure 6.3-5 SAMPLE DOCUMENTATION PROCESS CHECK SHEET (Page 3)

SOFTWARE PROBLEM REPORT

NUMBER 1

PROBLEM DISCOVERY | NAME OF FINDER 2 | PROJECT 3 | DATE 4

DESCRIPTION OF SYMPTOMS

5

PROBLEM ANALYSIS | NAME OF ANALYST 6 | DATE IN 7 | DATE OUT 8

ANALYSIS RESULTS

9

PROBLEM CORRECTION | NAME OF PROGRAMMER 10 | DATE IN 11 | DATE OUT 12

S/W FUNCTION: 13
- ☐ UTILITY
- ☐ COMPUTATIONAL
- ☐ LOGIC
- ☐ SIMULATION
- ☐ I/O
- ☐ EXEC
- ☐ OTHER

SOLUTION DESCRIPTION

14

NAME OF ROUTINE(S) CORRECTED 15 ____________

SIZE OF PROGRAM IN WHICH ERROR OCCURRED 16 ____

TEST PHASE WHEN ERROR FOUND: 17
- ☐ MODULE
- ☐ INTEGRATION
- ☐ SYSTEMS
- ☐ AFTER RELEASE

S/W TOOL USED TO ISOLATE ERROR 18

HOURS TO LOCATE ERROR — COMPUTER 19 ____ PERSON 20 ____

HOURS TO FIX ERROR — COMPUTER 21 ____ PERSON 22 ____

ERROR OCCURED IN 23
- ☐ REQUIREMENTS
- ☐ DESIGN
- ☐ CODE
- ☐ RECODE

CHANGES MADE TO: (CHECK ALL THAT APPLY) 24
- ☐ REQMTS
- ☐ DESIGN
- ☐ CODE

ERROR CATEGORY: 27
- ☐ COMPUTATIONAL
- ☐ LOGIC
- ☐ DATA INPUT
- ☐ DATA OUTPUT
- ☐ DATA HANDLING
- ☐ DATA DEFINITION
- ☐ ROUTINE/ROUTINE INTERFACE
- ☐ SOFTWARE/HARDWARE INTERFACE
- ☐ DATA BASE
- ☐ OPERATION
- ☐ DOCUMENTATION
- ☐ DUPLICATE (PREVIOUS SPR# ____)
- ☐ OTHER (PLEASE EXPLAIN BELOW)

IMPACT – LINES OF CODE CHANGED 25

PAGES OF DOCUMENTATION CHANGED 26

Figure 6.3-6 SAMPLE SOFTWARE PROBLEM REPORT

preliminary design). Customer approval of the baseline is an indicator of performance during the requirements task.

During the requirements analysis task each requirement is analyzed for compliance with specified criteria (see Section 17, Status Reviews, for a complete description of the criteria during a requirements review). Also, during this task the user requirements are refined and the requirements baseline is developed. Requirements analysis is performed prior to the Requirements Review with the customer. During this analysis, a form is completed for each requirement. The first page of the Requirements Analysis Form, shown in Figure 6.3-7, describes the requirement, its source, acceptance criteria, and approval signatures of the leader of the requirements definition team and the leader of the requirements analysis team. The second page of this form (see Figure 6.3-8) contains a checklist of the ten attributes of a requirement, questions to be answered by the requirements definition team, recommendations from the requirements analysis team and a statement about the feasibility of satisfying the requirement. Key IPAD individuals can easily ascertain the status of each requirement during the analysis effort and are able to monitor analysis progress by studying the Report. In addition, the performance of the requirements definition group can be indicated via the attribute checklist.

14. Technical, schedule and cost reports form the basis of status and progress evaluation for cost and schedule control.

A. 533-M (monthly) Report

The information is broken down to WBS level 2 and is also summarized at level 1 and for the total project. Cost data is broken down by cost element and computing labor is separated from engineering and manufacturing labor. The major cost elements are: 5 labor categories, material, computer cost, travel, 5 overhead and fringe benefit categories, and facilities cost. The report

REQUIREMENTS ANALYSIS FORM

NUMBER | SECTION | SOURCE(S)

REQUIREMENT

ACCEPTANCE CRITERIA FOR TESTING

CONCURRENCE

USER APPROVAL ______________________ DATE ______________

COMPUTING APPROVAL ________________ DATE ______________

Figure 6.3-7 SAMPLE REQUIREMENTS ANALYSIS FORM

REQUIREMENTS ANALYSIS CRITERIA CHECKLIST

REQUIREMENT NUMBER SECTION

COMPLETE

CORRECT

PRECISE, UNAMBIGUOUS, CLEAR

CONSISTENT

RELEVANT

TESTABLE

FEASIBLE

TRACEABLE

FREE OF DESIGN DETAIL

MANAGEABLE

QUESTIONS AND COMMENTS

FEASIBILITY

RECOMMENDATIONS

6.3-8 SAMPLE REQUIREMENTS ANALYSIS CRITERIA CHECKLIST

contains the number of hours expended in the various labor categories and the computer cost units expended. Figures 6.3-9(1), 6.3-9(2), and 6.3-9(3) illustrate samples of the 533-M report at WBS level 2, level 1, and for the total program, respectively. This report is also produced quarterly (533-Q). The monthly and quarterly reports have a standard content which is fixed by NASA and is part of IPAD's reporting requirement to NASA. From the reports, cost data can be extracted, manipulated and evaluated. The status of WBS level 1 and 2 tasks can easily be obtained. Comparison of current to past reports evidences progress. Performance can be partially viewed by comparison of budgeted to actual costs. The IPAD Business Manager uses data from the 533 reports to analyze the variance between actual and budgeted expenses. While it may seem a straightforward process of subtraction, this is not the case. A variance may be caused by many factors. A few examples are:

- a schedule slippage
- a labor rate change
- an overhead rate change
- overtime hours expended
- extra labor hours expended
- replanning causing rescheduling (i.e., execution of a task before or after its scheduled execution)

After variance analysis is complete, clear evidence of the program's progress and performance in relation to plan is available. Variance analysis presents the necessary indicators to explain why progress has varied from plan.

B. IPAD Integrated Resource/Schedule Status Report

This report summarizes schedule information on the upper portion of the page and resource data on the lower portion. Special symbols are used to portray milestones (contract and non-contract), schedule slides, and estimated completion dates (ahead or behind schedule). Planned and actual hour

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BOEING COMMERCIAL AIRPLANE COMPANY
(DIVISION OF THE BOEING COMPANY)
P.O. BOX 3707 SEATTLE, WASH. 98124

RESEARCH AND DEVELOPMENT 533-M REPORT

1.7 ENGR STANDARDS DEVELOPMENT
INTEGRATED PROGRAM FOR AEROSPACE - VEHICLE DESIGN (IPAD)

	DURING ACTUAL	AUG 1978 BUDGET	CUM THRU ACTUAL	AUG 1978 BUDGET	SEP ESTIMATE	OCT ESTIMATE	BAL-OF ESTIMATE	ESTIMATE AT COMPLETION	CONTRACT VALUE
ENG LABOR $									
MFG LABOR $									
FAB LABOR $									
INTERDIV SUPT $									
MATERIAL $									
COMPUTING $									
TRAVEL $									
OTHER DIRECT $									
TOTAL DIRECT $									
ENG O/H $									
MFG O/H $									
FAB O/H $									
G&A O/H $									
FRINGE $									
TOTAL O/H $									
COST-FACIL-CAP $									
MGMT RES $									
TOTAL PROG COST									
ENG LABOR HRS									
MFG LABOR HRS									
FAB LABOR HRS									

************************************** COMPUTING SUPPLEMENT TO COMPUTING DOLLARS **************************************

BCS LABOR $									
COMPUTER $									
TRAVEL $									
TOTAL COMP $									
PROGRAMMER LAB-HR									
6600 CU'S									

NOTES: 1. COMPUTER DOLLARS INCLUDE ALL NONLABOR COST EXCEPT TRAVEL WHICH IS DISPLAYED AS A SEPARATE COST ELEMENT.
2. CONTRACTOR RECORDS COMPUTING COSTS IN TOTAL AND NOT BY COST ELEMENT. COMPUTING COST ELEMENT DATA IS PREPARED FROM COMPUTING SUPPORT ORGANIZATION INTERNAL WORKING INFORMATION
3. 6600 CU'S ARE FOR NON-DEDICATED MACHINE USAGE.

THIS PAGE CONTAINS PRIVILEGED AND CONFIDENTIAL INFORMATION OF THE BOEING COMPANY
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Figure 6.3-9(1) SAMPLE 533-M REPORT (WBS LEVEL 2)

PAGE 2

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RESEARCH AND DEVELOPMENT 533-M REPORT

TASK I - DEFINITION & PREL DES
INTEGRATED PROGRAM FOR AEROSPACE - VEHICLE DESIGN (IPAD)

	DURING - AUG 1978 ACTUAL	DURING - AUG 1978 BUDGET	CUM THRU - AUG 1978 ACTUAL	CUM THRU - AUG 1978 BUDGET	SEP ESTIMATE	OCT ESTIMATE	BAL-OF ESTIMATE	ESTIMATE-AT COMPLETION	CONTRACT VALUE
ENG LABOR $									
MFG LABOR $									
FAB LABOR $									
INTERDIV SUPT $									
MATERIAL $									
COMPUTING $									
TRAVEL $									
OTHER DIRECT $									
TOTAL DIRECT $									
ENG O/H $									
MFG O/H $									
FAB O/H $									
G&A O/H $									
FRINGE $									
TOTAL O/H $									
COST-FACIL-CAP $									
MGMT RES $									
TOTAL PROG COST									
ENG LABOR HRS									
MFG LABOR HRS									
FAB LABOR HRS									

******************** COMPUTING SUPPLEMENT TO COMPUTING DOLLARS ********************

BCS LABOR $									
COMPUTER $									
TRAVEL $									
TOTAL COMP $									
PROGRAMMER LAB HR									
6600 CU'S									

NOTES: 1. COMPUTER DOLLARS INCLUDE ALL NONLABOR COST EXCEPT TRAVEL WHICH IS DISPLAYED AS A SEPARATE COST ELEMENT.
2. CONTRACTOR RECORDS COMPUTING COSTS IN TOTAL AND NOT BY COST ELEMENT. COMPUTING COST ELEMENT DATA IS PREPARED FROM COMPUTING SUPPORT ORGANIZATION INTERNAL WORKING INFORMATION
3. 6600-CU'S ARE FOR NON-DEDICATED MACHINE-USAGE.

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Figure 6.3-9(2) SAMPLE 533-M REPORT (WBS LEVEL 1)

PAGE 1

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RESEARCH AND DEVELOPMENT 533-M REPORT

TOTAL IPAD PROGRAM
INTEGRATED PROGRAM FOR AEROSPACE - VEHICLE DESIGN (IPAD)

	DURING ACTUAL	AUG 1978 BUDGET	CUM THRU ACTUAL	AUG 1978 BUDGET	SEP ESTIMATE	OCT ESTIMATE	BAL-OF ESTIMATE	ESTIMATE-AT COMPLETION	CONTRACT VALUE
ENG LABOR $									
MFG LABOR $									
FAB LABOR $									
INTERDIV SUPT $									
MATERIAL $									
COMPUTING $									
TRAVEL $									
OTHER DIRECT $									
TOTAL DIRECT $									
ENG O/H $									
MFG O/H $									
FAB O/H $									
G&A O/H $									
FRINGE $									
TOTAL O/H $									
COST-FACIL-CAP $									
MGMT RES $									
TOTAL PROG COST									
ENG LABOR HRS									
MFG LABOR HRS									
FAB LABOR HRS									

********** COMPUTING SUPPLEMENT TO COMPUTING DOLLARS **********

BCS LABOR $	
COMPUTER $	
TRAVEL $	
TOTAL COMP $	
PROGRAMMER LAB HR	
6600 CU'S	

NOTES: 1. COMPUTER DOLLARS INCLUDE ALL NONLABOR COST EXCEPT TRAVEL WHICH IS DISPLAYED AS A SEPARATE COST ELEMENT.
2. CONTRACTOR RECORDS COMPUTING COSTS IN TOTAL AND NOT BY COST ELEMENT. COMPUTING COST ELEMENT DATA IS PREPARED FROM COMPUTING SUPPORT ORGANIZATION INTERNAL WORKING INFORMATION
3. 6600 CU'S ARE FOR NON-DEDICATED MACHINE USAGE.

THIS PAGE CONTAINS PRIVILEGED AND CONFIDENTIAL INFORMATION OF THE BOEING COMPANY
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Figure 6.3-9(3) SAMPLE 533-M REPORT (TOTAL PROGRAM)

expenditures are graphically and numerically portrayed for easy comparison. A sample Integrated Resource/Schedule Status report is illustrated in Figure 6.3-10 for WBS task 1.7 (level 2 task). Status and progress are concisely shown and performance in relation to plan is highly visible.

C. Work Schedule Status Report

This report is produced weekly and provides indicators of status and progress. It is a computerized report which uses symbols to indicate task start, end, and intervening work. It is produced internally at WBS levels 4 and 3 and is summarized at level 2. Figure 6.3-11 illustrates the Work Schedule Status report at level 3, and summarized at level 2 for the period from January 1978 through September 1978. Notice that the four columns at the far right of the report separate manhours expended into engineering and computer programming categories. At completion, the budgeted and estimated manhours expended are provided.

This report provides quick status and progress visibility on a weekly basis and therefore is an invaluable management tool.

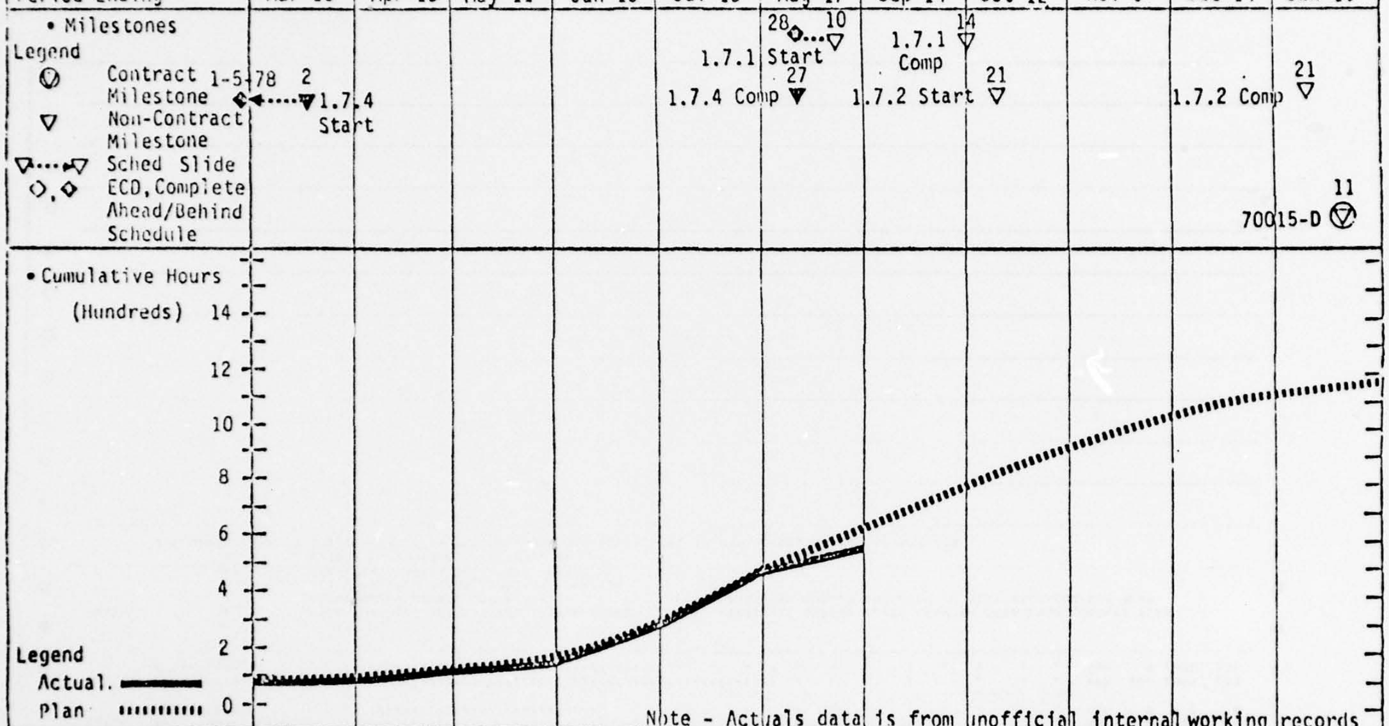
15. The findings of an independent test organization provide evidence of performance. Independent testing involves analysis of software requirements, administration and execution of tests, review of test results, inconsistency reporting and retesting as necessary until all requirements have been met. Independence of the test group from the software developers will introduce an unbiased evaluation of the capabilities and provide an indication of the performance of the software.

16. Checkpoint reviews are used to evaluate project activities. Performance is indicated by:
    - evaluation of project progress against schedule
    - resource usage evaluation

•IPAD INTEGRATED RESOURCE/SCHEDULE STATUS REPORT•

W.B.S. Number 1.7 | Responsible Manager S. Wahlstrom | Status Through 8-17-78

Title Engineering Standards Development



Year	1978										1979
Period Ending	Mar 16	Apr 13	May 11	Jun 15	Jul 13	Aug 17	Sep 14	Oct 12	Nov 9	Dec 14	Jan 18
Plan	87	112	146	292	457	585	786	910	1034	1188	1190
Actual	87	112	146	292	457	514					
Variance	-0-	-0-	-0-	-0-	-0-	(68)					
%PlanToDate/Plan@Comp	7	9	12	25	38	49					
%ActToDate/Plan@Comp	7	9	12	25	38	43					
% Complete	7	9	12	25	38	43					

Figure 6.3-10 SAMPLE INTEGRATED RESOURCE/SCHEDULE REPORT

```
                                 IPAD WORK SCHEDULE STATUS
                          SCHEDULE SUMMARY FOR ESTIMATES AND ACTUALS            THRU WEEK ENDING 78/09/14.

WBS      DESCRIPTION         J78 F  M  A  M  J  J  A  S  O  N  D78  J79 F  M  A  M  J  J      ENG  PRO  AT COMP
NUMBER                        .  .  .  .  .  .  .  .  .  .  .  .    .   .  .  .  .  .  .  .   M/M  M/M  EMH  PMH

1.7.1    DEVELOPMENT OF METHO- .  .  .  .  .  .  .  .X/////X  .  .  .   .   .  .  .  .  .  .  .   184  100  184  100
         DS                    .  .  .  .  .  .  .  X//////  .  . * .   .   .  .  .  .  .  .  .    12    0  184  100

1.7.2    IPAD ENGINEERING DEF- .  .  .  .  .  .  .  .  .  X/////////////X  .  .  .  .  .  .  .  .     0    0  404    0
         INITIONS              .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .     0    0  404    0

1.7.3    PLANNING AND DOCUMEN- .  .  .  .  .  .  .  .  .  .  .  .      .  .  .  .  .  .  .  .    72    0   72    0
         T OUTLINE             .  .  .  .  .  .  .  .  .  .  .  .      .  .  .  .  .  .  .  .    72    0   72    0

1.7.4    ADDITIONAL PLANNING   X/////////////////////////X.  .  .  .    .  .  .  .  .  .  .  .   430    0  430    0
         AND RESEARCH          .X////////////////////////X.  .  .  .    .  .  .  .  .  .  .  .   430    0  430    0

1.7      ENGINEERING STANDARD- ////////////////////////////////////////X  .  .  .  .  .  .  .  .   686  100 1090  100
         S DEVELOPMENT         ////////////////////////////////  .  .  . *  .  .  .  .  .  .  .  .   514    0 1090  100

NOTE.          X      WEEK THAT THE JOB STARTED AND/OR ENDED      S   BASELINE BUDGET START WEEK IF DIFF FROM CURRENT PLAN
               /      INTERVENING WEEKS, ONE PER WEEK             >   BASELINE BUDGET END WEEK IF DIFF FROM CURRENT PLAN
               .      JOB COMPLETED BEFORE THIS TIME PERIOD
               ..     JOB STARTS AFTER THIS TIME PERIOD
               *      LATEST ESTIMATE COMPLETION WEEK
         THE UPPER LINE IS THE CURRENT PLAN SCHEDULE AND THE LOWER LINE IS THE ACTUAL STATUS OF THE JOB
```

Figure 6.3-11 SAMPLE WORK SCHEDULE STATUS REPORT

- problem identification and correction

17. Status reviews, conducted by key individuals to review documentation, deliverables and project achievement, provide evidence of status and progress. Criteria which apply to particular reviews are normally specified prior to the review. For example, criteria which apply to the Requirements Document Review are:

A. Complete

All items that are needed for the specification of the requirements of the solution to the problem have been included.

B. Correct

Each item in the requirements specification is free from error.

C. Precise, unambiguous and clear

Each item is exact and not vague, there is a single interpretation of each item, the meaning of each item is understood and the specification is easy to read.

D. Consistent

No item conflicts with another item.

E. Relevant

Each item is pertinent to the problem and its solution.

F. Testable

During program development and acceptance testing, it will be possible to determine whether the item has been satisfied.

G. Traceable

Each item can be traced to its origin in the problem environment.

H. Feasible

Each item can be implemented with the techniques, tools, resources, and personnel that are available within the specified cost and schedule constraints.

I. Free of Unwarranted Design Detail

The requirements specifications are a statement of the requirements that must be satisfied by the problem solution and they are not obscured by proposed solutions to the problem.

J. Manageable

The requirements specifications are expressed in such a way that each item can be changed without excessive impact on another item. Changes to the completed specifications can be controlled. Each proposed change can be traced to an existing requirement and the impact of the proposed change can be assessed.

Achievement of each of these criteria provides indicators of performance for the specification and documentation of requirements.

18. A complete preliminary design is evidenced by many factors. A sample of these factors is given in a draft of the Software Development Procedure for a Preliminary Design Review for IPAD. A draft PDR document review checklist has been developed by IPAD. A summary of this checklist follows:

A. Are the PD objectives clearly stated?

B. Does the PD document contain a description of the procedure used to do PD or is there a reference to such a procedure?

C. Is there a list of functions to be provided by the computing system?

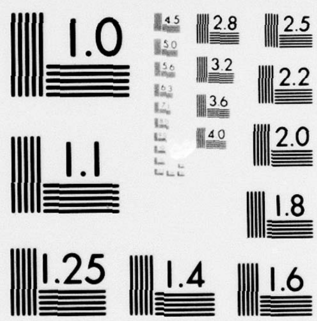
D. Is there a model of the user interface to the computing system?

E. Are there models and/or descriptions of all other interfaces to the computing system?

AD-A078 632 BOEING COMPUTER SERVICES INC SEATTLE WASHINGTON SYSTEMS ENGI--ETC. F/G 5/2
MANAGEMENT TOOLS CASE STUDY, (U)
SEP 79 J R BROWN, L S HAMMOND F30602-78-C-0044
UNCLASSIFIED RADC-TR-79-223 NL

2 OF 2
AD A
078632

END
DATE
FILMED
3-81
DTIC



MICROCOPY RESOLUTION TEST CHART

F. Is there a high-level functional model of the proposed computing system?

G. Are the major implementation alternatives and their evaluations presented in the document?

H. Is there a recommendation from the PD team to implement one of the alternatives?

I. Is the recommendation adequately supported?

J. Does the information presented in the PD document and during PDR give confidence that the computing system can be implemented to satisfy the requirements to such an extent that you would use the system?

19. Project Control/70 (a proprietary product of Atlantic Software, Inc.) is a software package used for project planning, reporting, analysis and accounting. The Project Status and Executive Summary Reports provide an accurate picture of project status and the current progress on a task basis. The Active Projects Due and Over Budget Reports highlight which tasks need special attention due to poor schedule or cost performance.

6.4 INDICATOR RESPONSIBILITY

Each of the indicators described earlier as being used by IPAD to assess status, progress and performance is the formal responsibility of one or more IPAD team member. These team members have been formally delegated the responsibility for establishment, control and maintenance of the indicators. Other team members have been formally directed to interpret program status, progress and performance indicators in specific areas. Figure 6.4-1 illustrates formally directed responsibilities for control and interpretation of the indicators.

It is important to remember that the many informal relationships between indicators and responsibilities have not been incorporated in Figure 6.4-1, since they are ill-defined. The matrix illustrates major responsibilities for indicators. Often an individual with responsibilities must have approval or input from one or more other IPAD individuals before his work will be consolidated into the IPAD framework.

RESPONSIBILITIES \ INDICATORS	PROJECT FILE	SOFTWARE NOTEBOOK	SUPPORT LIBRARY	PROJECT CONTROL ROOM	WALK-THROUGH	INSPECTIONS	QA REVIEWS and AUDITS	PROGRAMMING STANDARDS	USER, INDUSTRY and TECHNICAL INVOLVEMENT	DOCUMENTATION STANDARDS	SOFTWARE DEVELOPMENT TOOLS	COMPLETE PD and FD REVIEW	CONFIGURATION MANAGEMENT	REQUIREMENTS SPEC. BREAKOUT/TECHNICAL BASELINE	TECHNICAL, SCHEDULE and COST REPORTS	INDEPENDENT TESTING	CHECKPOINT REVIEWS	STATUS REVIEWS	PROJECT CONTROL/70
BUSINESS MANAGER (BM)	U			C											C,U			C,U	C,U
ITAB INTERFACE MANAGER (IIM)									C										
ENGINEERING DEVELOPMENT MANAGER/ASSISTANT PM (EDM)						U	U		U	U			U	C,U		U	U	U	C,U
SOFTWARE DEVELOPMENT MANAGER (SDM)							U		U						U		U	U	C*U
TECHNICAL DIRECTOR/CHIEF DESIGNER (CD)		U			C,U	C,U	U	C,U	U	U	C,U	C,U	U	C,U		U	C,U	C,U	C,U
INTEGRATOR/ASSISTANT CHIEF DESIGNER (AD)					C,U			U				C,U		U		C,U	C,U	U	C,U
PROGRAM SUPPORT MANAGER (PSM)	C,U		C				C						C						C,U
TECHNICAL LEADER-METHODS, STANDARDS (TL)		C			C*	C*		C*		C	C*						C	C	C,U

Legend

* = Leading responsibility, work approved by other managers who also have input.

C = Controls establishment and maintenance of indicator.

U = Responsible for use of indicator to assess status, progress and performance or to fulfill program responsibilities.

Figure 6.4-1 RELATIONSHIP OF FORMALLY DIRECTED RESPONSIBILITIES TO INDICATORS

This approval relationship is not depicted in the figure. Also, the matrix may depict an individual as being responsible for an indicator when the individual may delegate responsibility to his staff.

Figure 6.4-1 does not list the IPAD Program Manager (PM) as one of the responsible individuals. The PM has overall authority to control and establish each indicator. He uses data provided by each indicator to assess program status, progress and performance.

In a similar fashion, the NASA IPAD Project Office has an overall coordinating/monitoring function. They review and approve program products and use the data obtained from the indicators (which has been tabulated or summarized by IPAD) to assess progress, status and performance.

Additionally, various Boeing groups (i.e., Finance and Contracts) provide support in the areas of technical involvement, reviews, and technical, schedule and cost reports.

The Project Control/70 (PC/70) system provides reports to all individuals about resource planning and consumption as well as budget and expenditures for particular work unit tasks. Input to PC/70 comes from all of the IPAD team leaders and managers in the form of Work Authorizations (see Section 2.2.1.9) or via IPAD Task Resource Forms.

6.5 INDICATOR/OBJECTIVE RELATIONSHIP

Each of the indicators which IPAD is using to assess status, progress and performance has been applied in order to support achievement of one or more of the program objectives. Since the relationship between program objectives and management techniques has been surveyed (see Section 4.3), the relationship between indicators provided by the techniques and the program objectives can be inferred by

the results of the survey. Figure 6.5-1 illustrates the derived relationship between indicators and objectives.

When two techniques have been grouped together as one indicator, the surveyed responses have been combined also. For example, the techniques of User Involvement Planning and Industry and Technical Involvement have been grouped under the category of user, industry and technical involvement indicators. As Appendix E shows, both techniques were surveyed to be strongly supportive of the objective "Usefulness Demonstration." Therefore the combined group also has a strong relationship. When the surveyed relationship differs between the grouped techniques, the combined relationship must reflect this also. For example, User Involvement Planning was surveyed to be strongly related to the User Involvement objective, while Industry and Technical Involvement is only moderately related to the same objective. The combined relationship is strongly moderate, recorded as M+ in Figure 6.5-1. Other combined relationships have been similarly evaluated and recorded.

Since Project Control/70 was not surveyed along with the original candidate techniques, a strong or moderate relationship cannot be assessed in the same manner as other indicators. However, from conversations with IPAD program management and study of PC/70 literature, it has been determined that PC/70 is being used to achieve program objectives of cost, schedule, and visibility. Furthermore, the system is having widespread usage on IPAD, indicating that it strongly supports achievement of these objectives.

From study of Figure 6.5-1, a few observations may be made. First, seven of the objectives have a strong or strong-moderate relationship to at least one of the indicators. Of the six remaining objectives, 4 have 6-9 indicators which moderately relate to them.

The last two objectives, machine independence and contractor commitment, do not have a sufficiently observable relationship to any of the indicators. However,

OBJECTIVES \ INDICATORS	PROJECT FILE	SOFTWARE NOTEBOOK	SUPPORT LIBRARY	PROJECT CONTROL ROOM	WALK-THROUGH	INSPECTIONS	QA REVIEWS and AUDITS	PROGRAMMING STANDARDS	USER, INDUSTRY and TECHNICAL INVOLVEMENT	DOCUMENTATION STANDARDS	SOFTWARE DEVELOPMENT TOOLS	COMPLETE PD and PD REVIEW	CONFIGURATION MANAGEMENT	REQUIREMENTS SPEC. BASELINE	TECHNICAL, SCHEDULE and COST REPORTS	INDEPENDENT TESTING	CHECKPOINT REVIEWS	STATUS REVIEWS	PROJECT CONTROL/70
ON SCHEDULE							M										M	M	S*
UNDER COST															M		M		S*
USEFULNESS DEMONSTRATION					M				S										
STATUS VISIBILITY	M	M		S			S						M-		M		M	M	S*
USER INVOLVEMENT									M+					M					
STANDARD/PROCEDURE COMPLIANCE	M	M	M			M	M	M		M	M		M-						
RELIABILITY AND DEPENDABILITY		M	M		M		M	M			M					M			
CONFIGURATION MANAGEMENT	M	M	M										S						
SATISFY DIVERSE NEEDS									M+					M					
PROBLEM RECOGNITION AND CORRECTION					M	M	M		M-		M	M	M-				M		
MACHINE INDEPENDENCE																			
CONTRACTOR COMMITMENT									M-										
MAINTAINABILITY		M	M					M			M	M	M						

* Relationship determined via research, not through survey.

Figure 6.5-1 RELATIONSHIP BETWEEN INDICATORS AND OBJECTIVES

neither of these objectives fall into the category of the three highest-ranked objectives (see Section 4.1). Therefore, it is not surprising to find that they are not observably supported by indicators. Also, contractor commitment is more intangible than the rest of the objectives, therefore, less measurable.

The lack of indicators providing visibility into the objective of machine independence deserves closer scrutiny.

Generally, machine independence is supported by the adoption and use of programming standards. Explicit conformance to ANSI Standards will assure that no unique (machine dependent) features are designed into the system. However, only four survey participants indicated a strong or moderate relationship between standards and machine independence. This could be due to the fact that little formal auditing to standards is performed on IPAD. The participants may have felt that the informal auditing to be performed would not contribute significantly to machine independence.

6.6 MANAGEMENT TECHNIQUE INDICATORS

Each of the techniques used by IPAD was initiated to support achievement of an objective or set of objectives. As a whole, the techniques were designed and incorporated to provide status, progress and performance indicators (SPP indicators). While application of some of the techniques is more abstract than others, there exists (within IPAD) evidence of the use of the techniques.

Each of the techniques being used by IPAD was studied to determine ways in which the technique application could be evaluated. That is, management technique indicators (hereafter refered to as MT indicators) which would provide an unbiased evaluation of the "goodness" of technique application were identified. These MT indicators were in the form of data to be collected and critical questions which would determine whether the technique was providing any function not otherwise provided.

The list which follows identifies data which should be provided or critical functions which would be furnished by the use of a particular technique. The list is not necessarily a complete list of every MT indicator which would assess the application of each technique. It is, however, an unbiased list of generally-recognized data or functions which would allow evaluation of management techniques.

A. Project Manager Concept

1. Is there explicit use and delegation of authority?
2. Is there explicit definition of responsibility?

B. Work Breakdown Structure/Schedule

1. Is there any overlapping or redundancy of project tasks?
2. How much difficulty is there in obtaining the overall status of the project by determining the status of elements which make up the overall structure?
3. Are members of individual work units aware of how their units fit into the overall structure?

C. Programmers' Handbook

1. Are the requirements/specifications for this project centralized and easily ascertained by a programmer?
2. How long does it take to determine the tools and techniques available to the designer/programmer?
3. How long does it take to assemble the project development test guidelines?

D. Project File

1. How hard is it to find a particular item of correspondence about the project?
2. How long does it take to find out action items that have resulted from a particular review?

3. How long does it take to determine what changes have been made to the project SOW?

E. Software Notebook

1. How long does it take to determine the status of a particular module?
2. What effort has gone into code development and how long does it take to determine this information?
3. How long does it take to determine test case results for each module?

F. Support Library

1. How hard is it to obtain a copy of the official version of a program?
2. Can a history of controlled program changes be obtained?
3. How long does it take to obtain a list of the JCL needed to execute a program?

G. Work Authorization Form

1. How hard is it to find out when an item is scheduled for completion and what the total cost is estimated to be?
2. How does the cost of each item contribute to the total cost of the system?
3. Is there any work being done which is not specified or supported by Work Authorizations?

H. Project Control Room

1. How long does it take to determine the status of program cost and schedule?
2. How long does it take to obtain a conference room for a project meeting?

I. Walk-through/Inspections

1. How well do other programming group members understand the module logic and data flow of other members' code?

2. Is there a record of errors, discrepancies, and inconsistencies discovered during programming group reviews?

3. Does the code of the various members of the programmer team interface smoothly (or how many interface errors were detected)?

4. Do work products receive a formal approval or rejection as a result of inspections/walk-through?

J. Quality Assurance Reviews and Audits

1. Are quality assurance people aware of project status?

2. Do explicit measures of quality assurance exist?

3. Are quality assurance reports produced which document audit results?

K. Resource Allocation Sheets/Resource Requirements Summary

1. Is there consistent manloading of the project resources?

2. Can the job of an individual be determined by documentation at any point in time?

3. Have conflicts resulted due to lack of proper facilities at the needed time?

L. Programming Standards

1. Is there a standards manual or written programming instructions?

2. Are audits or tests performed to determine compliance to written standards?

3. Are records kept documenting non-standard programming practices used and detected?

M. Incremental Development

1. Are design component descriptions written as the last component produced plus a new capability?

2. Is any given design component independently testable?

N. User Involvement Planning/Industry and Technical Involvement

1. Do user, industry and technical people attend major component/project reviews?
2. Does documentation of user, industry and technical feedback, opinions and recommendations exist?
3. Is there a specific plan to involve these people in reviews and feedback?

O. Documentation Standards

1. Are there formal standards concerning the content and format of documentation?
2. Are the documents formally audited for compliance with content and format standards?

P. Design Representation and Testing Tools

1. Has a design representation scheme been adopted by the project?
2. Do programs exist which perform design analysis and consistency verification?
3. Is design documentation produced by a tool which would otherwise not exist?

Q. Complete Preliminary Design

1. Is there a Preliminary Design review conducted which checks PD completeness?
2. Are detailed design analysis results available?
3. How many sections of the PD have been specified as "to be completed" later?

R. Configuration Control

1. Are specific forms being used to identify, account for, control and verify changes to the project?
2. How long does it take to determine the current configuration?
3. How long does it take to effect a system change?

S. Requirements Specification Baseline

1. Is there customer approval of the requirements specification?
2. Is there a requirements document which follows established guidelines?
3. Do the requirements map back to a Software Specification or the Statement of Work?

T. Technical, Schedule and Cost Reports

1. Are technical, schedule and cost reports produced or is there a plan to produce them?
2. Is there a central collection organization which serves to collect data for these reports?
3. Is there some analysis of the content of these reports which shows that they are being used?
4. Is there cost, schedule or technical data available which would not otherwise have been produced?

U. Independent Test Evaluation

1. Is there an independent test group which is organizationally separate from the project team?
2. Is there a test plan which is derived from the requirements or which is derived independent of development and design effort?
3. Is there a test plan in existence prior to completion of design and development?

V. Project Checkpoints

1. Is there a chart which illustrates major project events during the project time frame?
2. Are major project deliverables identified?

W. Checkpoint Reviews

1. Is there a series of reviews which are associated to project checkpoints?

2. Is there some plan which specifies what reviews will be held and ties them to project deliverables or products?
3. Are there reports which were generated as a result of program product reviews?

X. Status Reviews

1. Are there project reviews which are held at regular intervals (i.e., monthly) or periodically due to a requirement to assess project status?
2. Are reports generated periodically which assess project status?

6.7 ADDITIONAL MANAGEMENT TECHNIQUE INDICATORS

The list of generally-recognized products or indicators of effective use of management techniques (see Section 6.6) was studied in relation to IPAD. If the products or indicators identified did not appear to be provided through the use of an IPAD technique, the need for an additional indicator of technique effectiveness was identified. In other words, if the answer to each of the preceding questions could be presently determined, no additional indicators would be required. The questions which could not be answered suggest that additional indicators are needed to assess the application of the techniques.

The identification of additional MT indicators needed does not imply a lack on the part of IPAD, since IPAD has not been commissioned to evaluate technique effectiveness. It does imply that more data would have to be collected than is presently available on the IPAD project.

The following additional MT indicators would be required for an evaluation of the application of management techniques:

1. Data would need to be collected to explicitly show the use and delegation of authority (refer to Question No. 1, Project Manager Concept). One way this might be illustrated would be to use the Management Responsibility Guide

(MRG). The MRG presents an approach to clarify the role each manager plays in relation to his work group and to the organization.

2. Some means would have to be developed to determine whether facilities were actually available when needed. This might be determined by talking with people to assess their satisfaction/dissatisfaction with facilities availability since no data exists which could be tabulated. (Refer to Question No. 3, Resource Allocation Sheets/PC/70.)

3. Some means for auditing of conformance to programming standards would have to be developed. (Refer to Question No. 1, Programming Standards.) Tools are in existence within the industry which document conformance to ANSI standards (i.e., PFORT verifier put out by Bell Labs) and to generally-accepted programming standards (i.e., TRW's Code Auditor). Specialized standards, however, would have to be manually audited. Some analysis of conformance to standards is performed during the design phases of IPAD. The IDAP tool, if used, would prohibit some non-standard constructs, and others may be pointed out during structured walk-throughs. However, no formal auditing of program code is performed.

4. In line with No. 3 above, no records are kept documenting non-standard programming practices detected. (Refer to Question No. 3, Programming Standards.) For example, no data showing how many non-standard lines of code exist is recorded. Output from tools like those referenced in No. 3 could be tabulated, if they were used.

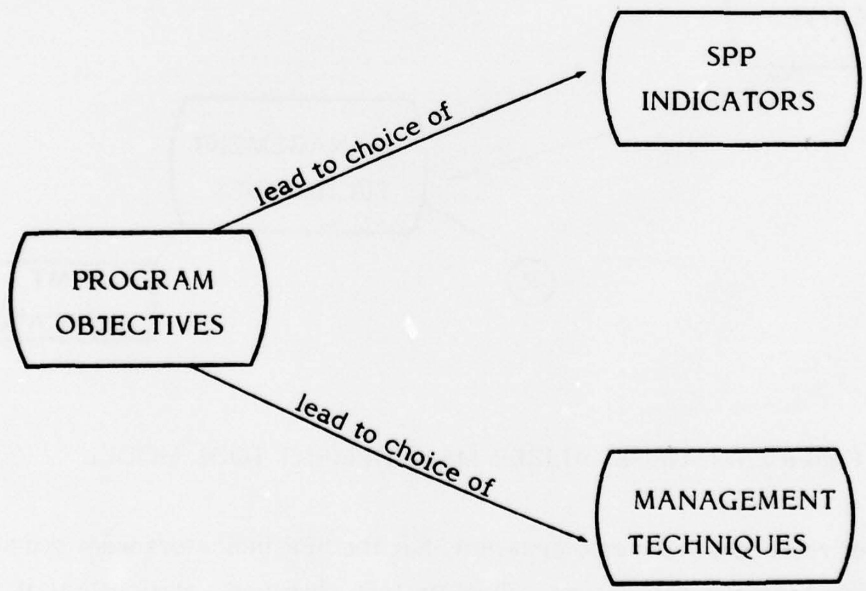
5. While documents are formally audited for conformance to content standards, no auditing of format standard conformance is performed. (Refer to Question No. 2, Documentation Standards.) This auditing would probably have to be performed manually and results tabulated.

6. A test group which is independent of the IPAD project does not exist and would, therefore, not be available for assessment purposes. However, the Configuration Control group (which is separate from actual development of IPAD software) is responsible for development and acceptance testing. Since the test group is not organizationally separate from IPAD, it is possible that sufficient indicators of the independent testing technique might not be available.

7.0 GENERALIZED MANAGEMENT TOOL MODEL

7.1 SELECTION OF TECHNIQUES AND INDICATORS

Management techniques are selected to support the program objectives (see Appendix E). Indicators of status, progress and performance are chosen to provide visibility into the achievement of program objectives (see Figure 6.5-1). Illustrated pictorially, these relationships and dependencies can be modeled as follows:



Program objectives are generally derived jointly during meetings between the Program Manager and the customer. SPP indicators are maintained and used by key individuals to monitor project development (see Figure 6.4-1). The development team is generally supported by management techniques during the project effort. If

the application of the techniques is to be evaluated, MT indicators are used. Incorporating elements of key responsibilities (R) and MT indicators into the model previously illustrated, Figure 7.1-1 results:

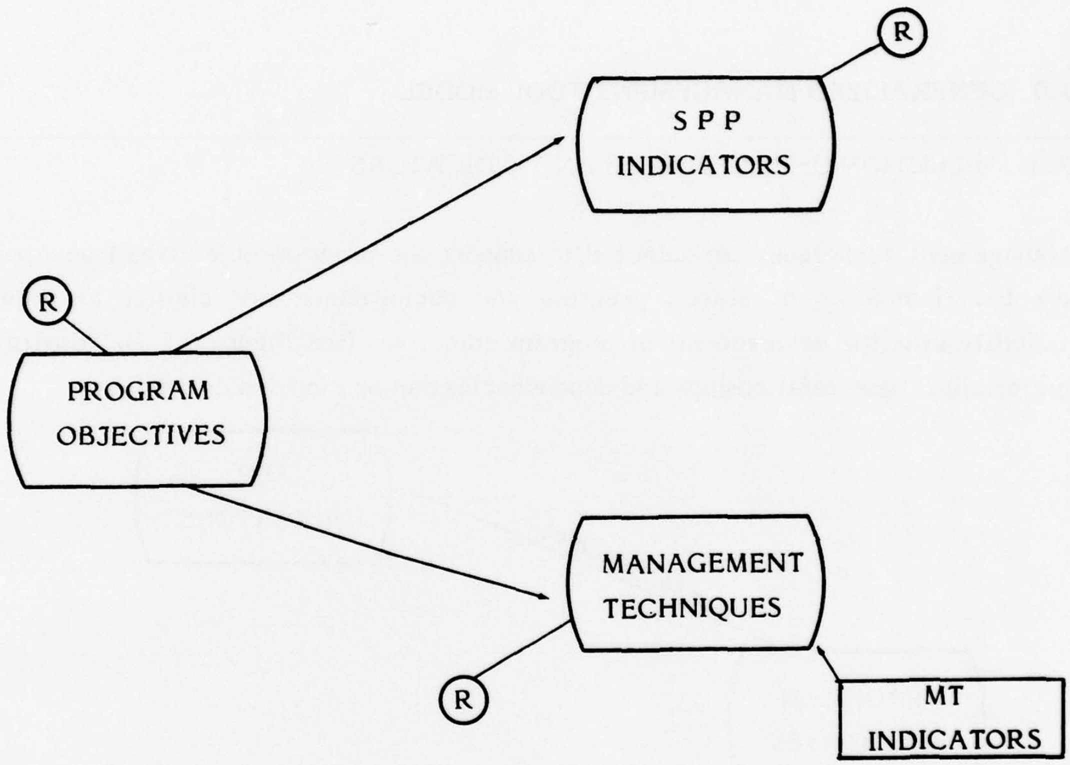


Figure 7.1-1 GENERALIZED MANAGEMENT TOOL MODEL

During earlier research, it became apparent that the SPP indicators were provided by the use of management techniques. Due to this observed relationship, it seems reasonable that the selection of SPP indicators and management techniques should be more closely associated. The selection of techniques should be based upon the SPP indicators chosen as well as on the program objectives.

Selection of techniques should begin by formulation of a set of program objectives. Next, those indicators which would provide visibility of the achievement of the objectives should be selected. Since the indicators are generally obtained through the implementation of management techniques, an initial set of techniques has also been determined. This set should be extended by inclusion of those techniques which directly support the objectives (see Appendix E).

To monitor the techniques, evidence of their application should be kept. This evidence, provided through MT indicators, should act as an early warning device of potential development problems.

To exemplify the use of the model illustrated in Figure 7.1-1, several scenarios have been developed using Appendix E and Figures 6.4-1 and 6.5-1.

Scenario A Data:

The customer and the Program Manager have compiled a list of program objectives. One objective is that of not expending more than the estimated cost of the development effort. Use of the matrix presented in Figure 6.5-1 shows that achievement of this objective is made visible through cost reports, checkpoint reviews of cost data, and use of Project Control/70 resource reports. These indicators are provided through the techniques of technical, schedule and cost reports, checkpoint reviews and the Project Control/70 system. From Figure 6.4-1 we determine that

- technical, schedule and cost reports are established and maintained by the Business Manager (with the finance group being the central collection agency). Furthermore, the reports are used by the Business Manager (BM) and the Software Development Manager (SDM) to assess status, progress and performance.

- Resource Requirements Allocation and PC/70 are established, maintained and used by all the managers except the ITAB Interface Manager.

The objective of meeting expected costs is supported by the following techniques as shown in Appendix E:

- Project Manager Concept
- Work Breakdown Structure/Schedule
- Work Authorization Forms
- Resource Allocation Sheets/Project Control/70
- Technical, Schedule and Cost Reports
- Project Checkpoints
- Checkpoint Reviews

The application of these techniques can be evaluated through the use of MT indicators.

1. Project Manager Concept MT Indicators:

   - Explicit use and delegation of authority
   - Explicit definition of responsibility

2. Work Breakdown Structure MT Indicators:

   - No overlapping or redundant tasks
   - Visible project status via determination of status of components
   - Individual component awareness of total project scope

3. Work Authorization MT Indicators:

   - Easy access to estimated completion dates and costs
   - Visibility into contribution of each component toward total system
   - No unauthorized work being performed

4. Resource Allocation MT Indicators:

- Consistent resource loading
- Easy determination of an individual's job at any point in time
- No conflicts due to facility availability

5. Technical, Schedule and Cost MT Indicators:

- Reports produced or a plan to produce them
- Centralized data collection organization
- Analysis of reports is performed
- Data produced which is otherwise unavailable

6. Project Checkpoint MT Indicators:

- Major project events identified and time frame for their occurrence documented
- Major deliverables identified

7. Checkpoint Review MT Indicators:

- Series of reviews associated with checkpoints
- Review plan in existence
- Reports produced documenting reviews

Inserting this scenario data into the model, Figure 7.1-2 results.

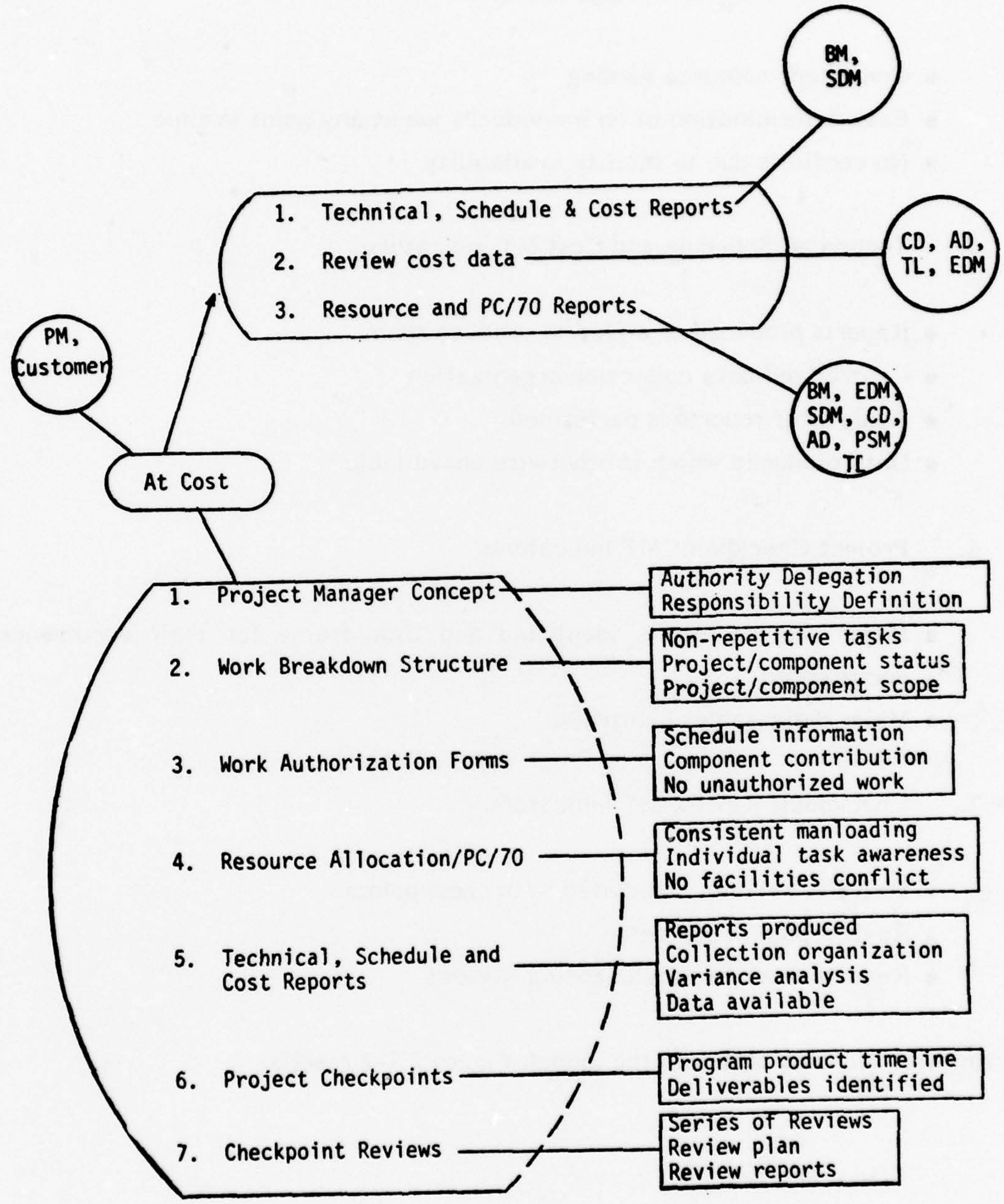


Figure 7.1-2 GENERALIZED MODEL OF SCENARIO A

Ideally, the MT indicators would be used to make the techniques self-monitoring. For example, the four indicators associated with technical, schedule and cost reports would continuously feed back information to the Business Manager (BM) and Software Development Manager (SDM). If the reports were not produced, the central organization not formed, analysis was not performed or data was not available the key individuals would know that the technique was not being used effectively. At this point steps would be taken to correct the situation.

However, most problems are not detected until the SPP indicators are viewed by individuals in charge of project assessment. The model presented will illustrate the resolution of problems and answering of questions made visible by the SPP indicators.

Using the data from Figure 7.1-2 it is possible to "walk-through" the model. For example, suppose the Business Manager receives a cost variance report stating that resource expenditures are greater than planned. He knows that the program objective of at cost is not being met. The Program Manager is informed and he determines that meeting the cost objective is supported by the following techniques; Project Manager Concept, Work Breakdown Structure, Work Authorization Forms, Schedule and Cost Reports, Project Checkpoints, Checkpoint Reviews, and Resource Allocation/Project Control/70. He also knows which individuals are concerned with establishment and usage of those techniques. He gathers these key individuals and tells them about the problem. He wants to know what caused the cost overrun and what could be done to prevent the problem in the future.

Various technical, schedule and cost reports would be reviewed by the BM and the SDM. Reports from previous checkpoint reviews would be gone over by the CD, AD, TL and EDM to determine whether there was any indication that a cost overrun would occur during the next checkpoint period. The Resource Allocation Sheets and the resource reports produced by the Project Control/70 system would be studied to determine whether more resources were expended than planned. One of the MT

indicators should point out the reason for the cost overrun and therefore provide a possible means of correction or way to prevent the situation from recurring.

The overrun could have been caused by an over expenditure of resources, or, some facility which should have been available might have been unavailable, causing delays. Or, a possible overrun might have been indicated in the previous review report. Another cause might have been faulty variance computations, or erroneous charging of resource expenditures.

Another scenario was developed to further illustrate the studied relationships. Data is presented and the generalized model is used to walk-through the scenario.

Scenario B Data

An objective developed by the Program Manager and the customer is that of machine independence. Although not observable by the survey performed on IPAD, this objective is generally made visible through auditing of conformance to industry-recognized standards (i.e., ANSI standards) and by walk-throughs. Programming standards are provided through the technique of programming/design standards. Several MT indicators provide evidence of the effective application of this technique:

1. Is there a standards manual or written programming instructions?

2. Are audits or tests performed to determine compliance to written standards?

3. Are records kept documenting non-standard programming practices used and detected?

MT indicators providing evidence of the effective application of structured walk-throughs are:

1. How well do other programming group members understand the module logic and data flow of other members code?

2. Is there a record of errors, discrepancies and inconsistencies discovered during programming group reviews?

3. Does the code of the various members of the programming team interface smoothly?

4. Do work products receive a formal approval or rejection as a result of walk-through?

From Figure 6.4-1, we determine that programming/design standards are established and maintained by the CD and the TL. Furthermore, the standards are used by the CD and AD to assess status, progress and performance.

Structured walk-through procedure is established and controlled by the TD, AD and TL. The results of the walk-throughs are reviewed and interpreted by the TD and AD.

Incorporating these elements into a generalized model, Figure 7.1-3 results.

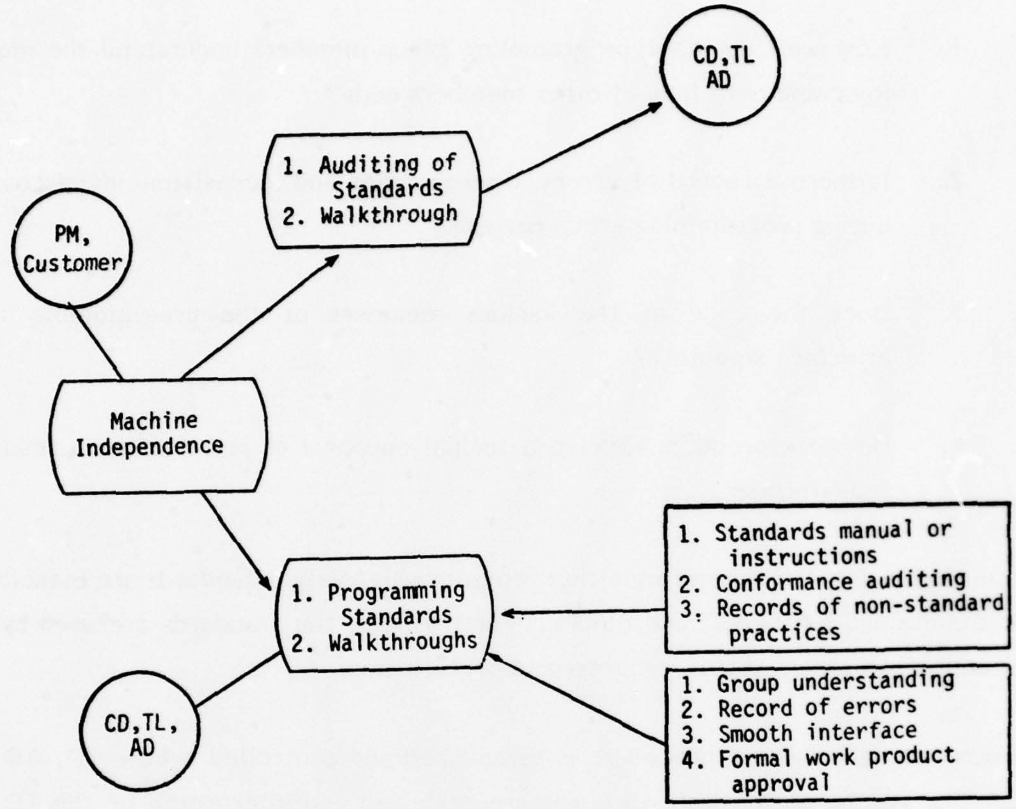


Figure 7.1-3 GENERALIZED MODEL OF SCENARIO B

This model can be used to illustrate the development process in the event of a software problem or question. For example, suppose the Chief Designer (CD), while reviewing a software module, detected the use of a non-standard programming practice. He knows that the use of non-standard programming practices often effects the portability of software. In essence, the software could become machine dependent. The objective of machine independence is supported by the use of programming standards and walk-throughs. The CD and AD are notified of the standards violation and are held responsible for resolving the problem. They would check the standards manuals, reports from any previous auditing, and reports generated from the associated walk-through review. The walk-through review report might contain an indication of why the non-standard practice was used. The CD and AD must determine whether or not a valid reason exists to allow usage of non-standard practices. Depending on their determination, the practice will either be changed or made highly visible through documentation.

7.2 SUMMARY

The generalized management tool model developed in 7.1 can be used to summarize the studied relationships between SPP Indicators, program objectives, management techniques, MT Indicators, and key responsibilities. This model illustrates the studied relationships but does not incorporate all the elements of planning, production and assessment of the software development process. These elements will be the topic of future research.

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APPENDIX A
SUMMARY OF RESPONSES TO PART ONE OF SURVEY

DEVELOPMENT/ MANAGEMENT OBJECTIVES	NUMBER OF RESPONSES			
	HIGH	MEDIUM	LOW	UNCERTAIN
ON SCHEDULE	5	5	3	
UNDER COST	4	4	5	
STATUS VISIBILITY	4	2	6	1
PROBLEM RECOGNITION AND CORRECTION	4	7	2	
CONTRACTOR COMMITMENT	6	5	2	
USER INVOLVEMENT	6	6	1	
USEFULNESS DEMONSTRATION	7	4	2	
SATISFY DIVERSE NEEDS	9	3	1	
STANDARD/PROCEDURE COMPLIANCE	2	3	7	1
RELIABILITY AND DEPENDABILITY	7	2	3	1
CONFIGURATION MANAGEMENT	4	4	5	
MACHINE INDEPENDENCE	2	2	9	
MAINTAINABILITY	4	3	5	1

APPENDIX B

SUMMARY OF RESPONSES TO PART TWO OF SURVEY

	TECHNIQUE BEING APPLIED OR PROPOSED TO BE APPLIED	TECHNIQUE NOT BEING APPLIED	NUMBER OF PARTICIPANTS WITH NO PERSONAL KNOWLEDGE OF TECHNIQUE
PROJECT MANAGER CONCEPT	10	0	0
WORK BREAKDOWN	10	0	0
EGOLESS TEAMS	6	2	2
CHIEF PROGRAMMER TEAMS	3	4	3
PROGRAMMER'S HANDBOOK	9	0	1
PROJECT FILE	9	0	1
SOFTWARE NOTEBOOK	8	0	2
SUPPORT LIBRARY	10	0	0
PERSONNEL REQUIREMENTS FORM	1	8	1
WORK AUTHORIZATION FORM	9	1	0
PROJECT CONTROL ROOM	10	0	0
WALK THROUGH	9	0	1
INSPECTIONS	9	0	1
REVIEWS AND AUDITS	10	0	0
RESOURCE ALLOCATION SHEETS	10	0	0
RESOURCE REQUIREMENTS SUMMARY	10	0	0
PROGRAMMING STANDARDS	10	0	0
INCREMENTAL DEVELOPMENT	10	0	0
USER INVOLVEMENT PLANNING	10	0	0
INDUSTRY AND TECHNICAL INVOLVEMENT	10	0	0
DOCUMENTATION STANDARDS	10	0	0
REQUIREMENTS DEFINITION AND ANALYSIS TOOLS	3	6	1
DESIGN REPRESENTATION AND TESTING TOOLS	6	2	2
COMPLETE PRELIMINARY DESIGN	9	0	1
CHANGE CONTROL BOARD	10	0	0
BLOCKPOINT CHANGE CONTROL	8	0	2
REQUIREMENTS SPECIFICATION BASELINE	10	0	0
TECHNICAL, SCHEDULE & COST REPORTS	10	0	0
INDEPENDENT TEST EVALUATION	9	0	1
PROJECT CHECKPOINTS	9	0	1
CHECKPOINT REVIEWS	9	0	1
STATUS REVIEWS	10	0	0

APPENDIX C

SUMMARY OF RESPONSES TO PART THREE OF SURVEY

NASA AND IPAD PROJECT OBJECTIVES \ IPAD MANAGEMENT TOOLS	PROJECT MANAGER CONCEPT	WORK BREAKDOWN	EGOLESS TEAMS	CHIEF PROGRAMMER TEAMS	PROGRAMMER'S HANDBOOK	PROJECT FILE	SOFTWARE NOTEBOOK	SUPPORT LIBRARY	PERSONNEL REQUIREMENTS FORM	WORK AUTHORIZATION FORM	PROJECT CONTROL ROOM	WALK-THROUGH	INSPECTIONS	REVIEWS AND AUDITS	RESOURCE ALLOCATION SHEETS	RESOURCE REQUIREMENTS SUMMARY
ON SCHEDULE	8/3	5/4	0/1	1/1	0/3	0/4	1/2	1/3	1/0	3/2	3/2	1/0	1/2	5/2	5/0	3/5
UNDER COST	9/3	3/4	0/1	1/1	0/3	0/3	1/2	1/3	0/0	4/4	1/3	0/1	0/2	3/3	6/3	3/3
USEFULNESS DEMONSTRATION	0/3	1/1	0/1	0/0	0/1	0/1	0/1	1/2	0/0	0/0	0/1	2/5	1/2	1/5	0/1	1/1
STATUS VISIBILITY	7/2	5/3	0/2	1/2	2/1	7/2	4/5	2/2	0/1	3/1	8/4	4/0	3/2	7/4	4/2	3/3
USER INVOLVEMENT	3/3	1/1	0/1	0/0	0/1	0/1	0/3	0/3	0/0	0/0	1/1	1/4	1/3	4/3	0/1	0/2
STANDARD/PROCEDURE COMPLIANCE	4/4	0/1	2/2	1/1	7/3	4/2	5/2	6/2	0/0	2/1	2/3	8/0	4/2	5/4	1/1	1/1
RELIABILITY AND DEPENDABILITY	0/3	0/1	3/1	1/5	1/4	1/3	5/3	5/1	0/0	0/0	0/1	3/4	3/2	2/5	0/1	0/1
CONFIGURATION MANAGEMENT	6/2	2/1	0/1	0/1	3/3	4/3	4/2	6/2	0/0	1/1	1/3	1/1	0/2	0/3	1/1	1/1
SATISFY DIVERSE NEEDS	2/2	0/2	1/1	1/0	0/1	0/1	0/1	0/1	0/0	0/0	0/1	0/2	0/2	2/3	0/1	1/0
PROBLEM RECOGNITION AND CORRECTION	5/2	0/2	2/2	2/1	1/1	3/1	3/1	2/1	0/0	0/1	2/4	5/2	6/1	6/2	1/3	1/3
MACHINE INDEPENDENCE	0/2	0/1	1/2	1/0	2/3	0/2	1/4	0/3	0/0	0/0	0/1	1/3	1/4	1/4	0/1	1/2
CONTRACTOR COMMITMENT	7/3	1/2	0/2	1/1	1/1	2/2	1/1	0/2	0/0	1/0	1/3	1/1	1/1	3/2	1/1	1/1
MAINTAINABILITY	0/2	0/2	1/4	1/1	3/1	3/1	4/1	4/2	0/0	0/0	0/1	2/1	2/3	2/2	0/1	0/1

NASA AND IPAD PROJECT OBJECTIVES \ IPAD MANAGEMENT TOOLS	PROGRAMMING STANDARDS	INCREMENTAL DEVELOPMENT	USER INVOLVEMENT PLANNING	INDUSTRY AND TECHNICAL INVOLVEMENT	DOCUMENTATION STANDARDS	REQUIREMENTS DEFINITION AND ANALYSIS TOOLS	DESIGN REPRESENTATION AND TESTING TOOLS	COMPLETE PRELIMINARY DESIGN	CHANGE CONTROL BOARD	BLOCKPOINT CHANGE CONTROL	REQUIREMENTS SPECIFICATION BASELINE	TECHNICAL, SCHEDULE & COST REPORTS	INDEPENDENT TEST EVALUATION	PROJECT CHECKPOINTS	CHECKPOINT REVIEWS	STATUS REVIEWS
ON SCHEDULE	2/2	3/3	8/2	0/1	0/3	0/3	0/2	2/4	0/3	1/1	1/1	6/3	0/2	5/3	5/4	3/6
UNDER COST	2/1	1/2	0/2	0/1	0/4	1/2	0/2	2/4	0/3	0/3	1/3	4/3	0/1	3/4	3/4	2/2
USEFULNESS DEMONSTRATION	0/2	3/3	9/2	9/3	1/3	1/3	1/3	2/1	0/1	0/1	3/1	0/1	3/1	1/1	1/1	1/2
STATUS VISIBILITY	0/1	4/2	0/4	0/4	0/3	0/2	0/3	1/2	3/4	3/2	0/4	6/2	1/2	5/1	4/2	6/2
USER INVOLVEMENT	0/1	2/3	12/1	7/2	1/3	1/1	0/1	2/3	2/3	0/2	6/2	0/2	2/3	3/0	2/1	2/1
STANDARD/PROCEDURE COMPLIANCE	7/0	2/1	0/2	0/2	9/0	3/0	4/2	2/2	5/2	3/2	1/1	0/2	2/2	1/3	1/4	0/4
RELIABILITY AND DEPENDABILITY	5/2	1/5	1/2	1/1	0/3	2/2	4/3	2/3	2/2	0/3	1/2	0/1	4/3	2/1	1/1	1/1
CONFIGURATION MANAGEMENT	3/1	2/3	0/3	1/3	2/3	0/1	1/1	2/2	10/1	10/1	1/4	0/2	2/2	0/2	0/1	0/1
SATISFY DIVERSE NEEDS	0/1	1/2	9/1	9/0	0/1	2/1	0/1	3/2	0/2	0/2	4/2	0/1	2/0	1/0	1/1	1/1
PROBLEM RECOGNITION AND CORRECTION	2/1	2/3	2/5	3/3	1/2	1/3	4/2	5/3	4/3	3/2	1/3	2/2	2/3	3/3	3/4	2/3
MACHINE INDEPENDENCE	2/2	0/2	0/1	2/1	1/1	1/0	0/2	1/1	0/2	0/2	0/2	0/1	1/2	0/2	1/3	0/2
CONTRACTOR COMMITMENT	0/2	0/2	3/2	4/3	1/1	0/1	0/1	1/1	0/1	0/1	0/1	1/1	0/1	1/3	0/3	1/1
MAINTAINABILITY	8/0	1/5	0/1	0/2	2/2	1/2	5/2	6/1	3/4	4/3	2/2	1/1	1/5	1/3	1/3	1/2

S/M: S = TOTAL STRONG POSITIVE RESPONSES; M = TOTAL MODERATE POSITIVE RESPONSES

APPENDIX D

SUMMARY OF ALGORITHM INDICES FOR PART THREE OF SURVEY

NASA and IPAD Project Objectives \ IPAD Management Tools	Project Manager Concept	Work Breakdown	Egoless Teams	Chief Programmer Teams	Programmer's Handbook	Project File	Software Notebook	Support Library	Personnel Requirements Form	Work Authorization Form	Project Control Room	Walk-through	Inspections	Reviews and Audits	Resource Allocation Sheets	Resource Requirements Summary
On Schedule	.59	.34				.03								.23	.15	.22
Under Cost	.71	.18								.25					.37	
Usefulness Demonstration												.15		.09		
Status Visibility	.41	.28				.41	.30				.66	.09		.54	.17	
User Involvement												.07				
Standard/Procedure Compliance	.25				.47	.17	.23	.32					.17	.34		
Reliability and Dependability					.07		.28	.19				.18		.15		
Configuration Management	.32					.21	.17	.32								
Satisfy Diverse Needs																
Problem Recognition and Correction	.23										.12	.23	.26	.32		
Machine Independence							.07						.07	.07		
Contractor Commitment	.47															
Maintainability							.19	.17								

NASA and IPAD Project Objectives \ IPAD Management Tools	Programming Standards	Incremental Development	User Involvement Planning	Industry and Technical Involvement	Documentation Standards	Requirements Definition and Analysis Tools	Design Representation and Testing Tools	Complete Preliminary Design	Change Control Board	Blockpoint Change Control	Requirements Specification Baseline	Technical, Schedule & Cost Reports	Independent Test Evaluation	Project Checkpoints	Checkpoint Reviews	Status Reviews
On Schedule								.12						.28	.34	.27
Under Cost					.03			.12				.21		.13	.18	
Usefulness Demonstration			.63	.71												
Status Visibility		.17	.03	.03					.18		.03	.32		.19	.17	.32
User Involvement			.95	.41							.32					
Standard/Procedure Compliance	.29				.48				.23						.07	.03
Reliability and Dependability	.23	.09											.21			
Configuration Management									.67	.67						
Satisfy Diverse Needs			.55	.48							.17					
Problem Recognition and Correction			.15					.28	.21						.18	
Machine Independence																
Contractor Commitment				.21												
Maintainability	.38	.09						.26	.18	.21			.09			

APPENDIX E

SUMMARY OF STRONG AND MODERATE RESPONSES TO PART THREE OF SURVEY

NASA and IPAD Project Objectives / IPAD Management Tools	Project Manager Concept	Work Breakdown	Egoless Teams	Chief Programmer Teams	Programmer's Handbook	Project File	Software Notebook	Support Library	Personnel Requirements Form	Work Authorization Form	Project Control Room	Walk-through	Inspections	Reviews and Audits	Resource Allocation Sheets	Resource Requirements Summary	Programming Standards	Incremental Development	User Involvement Planning	Industry and Technical Involvement	Documentation Standards	Requirements Definition and Analysis Tools	Design Representation and Testing Tools	Complete Preliminary Design	Change Control Board	Blockpoint Change Control	Requirements Specification Baseline	Technical, Schedule & Cost Reports	Independent Test Evaluation	Project Checkpoints	Checkpoint Reviews	Status Reviews
On Schedule	S	M												M	M	M														M	M	M
Under Cost	S	M								M					M													M		M	M	
Usefulness Demonstration												M							S	S												
Status Visibility	M	M				M	M				S			S	M			M							M			M		M	M	M
User Involvement																			S	M							M					
Standard/Procedure Compliance	M				M	M	M	M					M	M			M				M				M							
Reliability and Dependability							M	M				M		M			M												M			
Configuration Management	M					M	M	M																	S	S						
Satisfy Diverse Needs																			S	M							M					
Problem Recognition and Correction	M											M	M	M					M					M	M						M	
Machine Independence																																
Contractor Commitment	M																			M												
Maintainability							M	M									M							M	M	M						

S = STRONG POSITIVE EFFECT

M = MODERATE POSITIVE EFFECT

Appendix F

Hypothetical IPAD Situation Scenarios

1. A Critical Design/Development Review (CDR) was scheduled to review detailed design documentation. Present at the review were members of the IPAD technical and management teams and representatives from NASA. During the CDR, NASA proposed a change to the IPAD requirements. This change was requested in order to restate a requirement to meet a need which had been thought to be covered by a combination of other requirements. IPAD team members agreed that the need would not be satisfied by the current requirements. The resulting action item was to evaluate, formally state and incorporate the proposed requirements change.

2. A meeting of the IPAD Technical Advisory Board (ITAB) was scheduled and held to comment on and review the Reference Design Process Document. During this meeting, one of the ITAB members pointed out a deficiency in the design process. The committee agreed that the deficiency should be reported to IPAD and a letter to the IPAD Program Manager and the NASA Project Manager was written.

3. A Preliminary Design Review (PDR) was scheduled and held. Members of IPAD Management and technical teams and NASA were present. Some members of ITAB were also involved. The customer (NASA) was concerned about what had been "designed into" IPAD software to insure reliability and maintainability. Members of IPAD assured NASA that the use of rigid programming and engineering standards would make IPAD easily maintainable, and that other techniques were being used to ensure reliability. NASA indicated a strong interest in development and

application of thorough testing procedures and requested a demonstration that sufficient test case coverage was achieved. It was determined that the PDR action item was a) to define an acceptable measure of testing sufficiency and b) to update IPAD management and technical plans accordingly.

Appendix G

Process of the Action Item (AI) for Scenario #1

Step(s)	Action Taken
1.	NASA CDR Board Chairman gives Action Item to IPAD Program Manager.
2.	IPAD Program Manager turns AI over to Assistant Program Manager for technical evaluation and routing.
3.	Assistant Program Manager forwards AI to Software Development Manager for evaluation and task delegation.
4.	Software Development Manager assigns task of Formal Statement to manager responsible for IPAD Requirements and Requirements Documentation.
5.	Requirements Manager delegates Formal Statement responsibility to IPAD computing staff member.
6.	IPAD computing staff member prepares Formal Statement of Requirement for Requirements Manager, and contacts Program Control Coordinator (PCC) for CCR Form because Requirements Document is under Configuration Control.

Appendix G (Continued)

Step(s)	Action Taken
7.	The PCC and computing staff member fill out the Configuration Change Request (CCR) and Impact Summary and submit them to the Requirements Manager for his appraisal of initial impact.
8.	Requirements Manager fills out anticipated impact on the CCR Form and Management Summary on Impact Analysis Form and returns the CCR package to the PCC.
9.	The PCC logs the CCR in Configuration Control Log. The PCC makes 10 copies of proposed Change Package and distributes this to managers with notification of Configuration Change Board Meeting.
10.	The Configuration Change Board (CCB) considers the proposed Change Package and orders a full impact analysis if they think it necessary, or they pass and sign the CCR and Impact Summary forms and the package is routed on by the PCC.
11.	The PCC logs the Board decision and if passed he will route to the Program Manager for concurrence signature.

Appendix G (Continued)

Step(s)	Action Taken
12.	Program Manager reviews the CCR Package, signs and returns to the PCC for forwarding to NASA. (Changes to Formal Configured Items are Level I and require NASA approval.)
13.	The PCC takes the approved package, logs the Program Manager's signature and date, makes a copy of the Package in its approved form and sends the original to NASA.
14.	NASA considers change package and either rejects or accepts it. If accepted it will be returned to the PCC at Boeing, usually within 30 days.
15.	The PCC then takes the Accepted Package and turns it over to an ATMS (Automated Text Management System) typist and she makes the changes or in this case additions to the Master File for this document on ATMS, returning the text and the CCR to the PCC for collation with revised graphics originals and the PCC will route revised doucment master to responsible manager for his approval. If the responsible manager is satisfied with the document he will O.K. a release of the revised document.

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Appendix G (Continued)

Step(s)	Action Taken
16.	The PCC will then send the revised document master to printing where 200 (approximately) copies will be made and sent back to the PCC. It is then his responsibility to see that everyone who has been issued the document in the past receives an updated copy.

Appendix G (Continued)

Actions in Response to Scenario #2

Step(s)	Action Taken
1.	ITAB Interface Manager sends action item to Program Manager and NASA.
2.	Program Manager assigns the Engineering Development Manager to correct Reference Design Process document as required and establish modifications (if any) required for the requirements documentation.
3.	Engineering Development Manager opens an authorized study account number and assigns study and plan task to engineer.
4.	PCC and Engineering Development Manager fill out CCR and cost and impact estimates are made (see response to Scenario #1, steps 6-9).
5.	CCB meets and decides what to do. Assume document update and update of dependent documents is proposed.
6.	Engineering Development Manager opens an authorized account number for a doing task, assigns task to engineer. Result is a CCR of document updates.

Appendix G (Continued)

Step(s)	Action Taken
7.	CCB meets and approves the update.
8.	Program Manager and NASA approve.
9.	Configuration control function carries out document update.
10.	Changes reported to next ITAB meeting.

Appendix G (continued)

Actions in Response to Scenario #3

Functional events or steps to resolve the third scenario were not detailed. In essence, very little could be learned from the third scenario which had not already been illustrated by Scenarios #1 and #2.

A group would have been assembled to study the existing testing procedures. The Development Test Plan and the Acceptance Test Plan would have been reviewed. If the existing procedures had been satisfactory the procedures would have been documented and resubmitted to the customer. If unsatisfactory, new procedures would have been studied, developed, approved and incorporated into existing Test Plans. The procedure for change procedure has already been documented as a part of Scenario #1.

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